POWER

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N.A.S.E.
Proclamation
IN THE NAME OF PEACE, PROGRESS AND PROSPERITY THE N.A.S.E. WILL MOBILIZE AT MILWAUKEE, WIS., SEPT. 7, 1914
I PUT THE MOB IN MOBILIZE
McPhee
POWER N.Y.

FOR PEACE, PROGRESS AND PROSPERITY!

Milwaukee's Largest Electric Station

SYNOPSIS—The Commerce St. station, Milwaukee's largest power station, has a generating capacity of 61,900 kw. and 17,000 hp. in boilers. Large low-pressure turbines take steam from cross-compound vertical engines; special governors control the supply. The coal- and ash-handling facilities are interesting. Individual steel stacks for each battery of two boilers are provided. Continuous smoke records are kept and a bonus system, which has resulted in efficient operation, is in force in the boiler room.

The Commerce St. station of the Milwaukee Electric Ry. & Light Co. is on the west bank of the Milwaukee River, a short distance north of the central business district of the city. It is the main generating station for this company and its subsidiaries, and is of 61,900-kw. capacity, 6000 kw. being in 25-cycle engine-driven units, 8000 kw. in 600-volt, direct-current, engine-driven generators; 15,000 kw. in 25-cycle turbo-generators, 32,500 in 60-cycle turbo-generators, and the remaining 400 kw. is an engine-driven unit furnishing 250-volt direct current for station use. The construction of the present plant may be divided into three main periods, although various pieces of apparatus have been added at different times when needed.

The first installation was four 1500-kw., engine-driven, 25-cycle alternators and eight 650-hp. boilers, placed in use early in 1903. Two years later four more engines, this time driving 2000-kw., 600-volt railway generators, and eight 708-hp. boilers were installed. A short time later two 1000-kw., vertical-impulse turbines were added to provide for the 60-cycle demand formerly met by the other stations. The final period of construction was in 1911 and 1912, which more than doubled the old capacity and left the station in practically its present condition. At this time all of the barometric condensers but one and the two 1000-kw. vertical turbines were removed. Two 14,000-kw., high-pressure, 60-cycle, vertical turbo-generators, Fig. 1, and two 7500-kw., low-pressure, 25-cycle turbo-generators, Fig. 2, were installed, together with eight 765-hp. boilers and auxiliaries. Since that time a 4500-kw. turbine has been added to the 60-cycle system and a 400-kw. engine has been transferred from one of the other stations to provide 250-volt direct current for station use. Twenty-five-cycle power is also received over a 120-mile transmission line from the hydro-electric station of the Southern Wisconsin Power Co., on the Wisconsin River at Kilbourn.

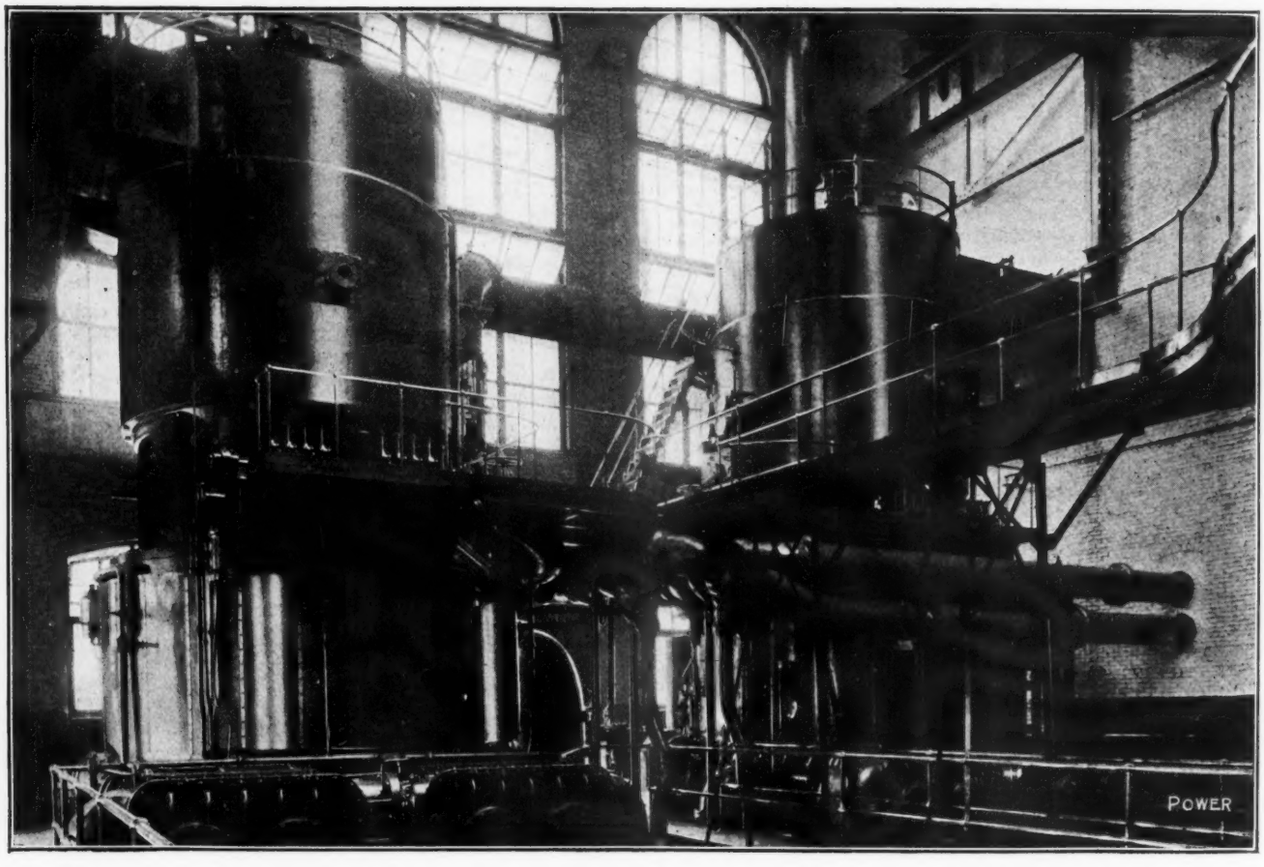


FIG. 1 14,000-KW., HIGH-PRESSURE TURBINES IN NORTH END OF STATION

ENGINE ROOM

Fig. 3 is a view over the tops of the engines and shows the large exhaust pipe with the two atmospheric reliefs. The section of pipe between the last engine and the large receiver separator is 66 in. in diameter, and is fitted with a motor-operated valve of the same size. Seven engines exhaust into this header. Part of the barometric con-

denser for engine No. 1 can be seen at the extreme end. This engine drives a 1500-kw., 25-cycle alternator, and is used when the load is too light to justify the operation of both an engine and a low-pressure turbine, as is the case in the early morning hours, when the 25-cycle load is generally carried by the transmission line. Besides the connections from the seven engines, the auxiliary exhaust header leads into the main line, so that all of the steam not utilized in the feed-water heaters can be used in the turbines. Fig. 4 is a plan view of the entire station, showing the layout of all the engines, turbines, boilers and auxiliaries. Fig. 5 is a cross-section of the north end of the plant.

The low-pressure turbines, Fig. 2, are of the 4-stage, vertical-impulse type, and drive 25-cycle, 6600-volt generators, compensators being used to step up to 13,200 volts, the standard voltage at which this current is transmitted. The two 14,000-kw. machines, Fig. 1, are 6-stage, high-pressure vertical units of the same type, and together with the 4500-kw. turbine shown in Fig. 6, which is a horizontal reaction machine, generate 60-cycle power at 4000 volts, the standard voltage for primary distribution in the city. The 4500-kw. unit was installed to carry the load during the early morning hours and on holidays, and is also used to help out the large turbines at times of peak demand.

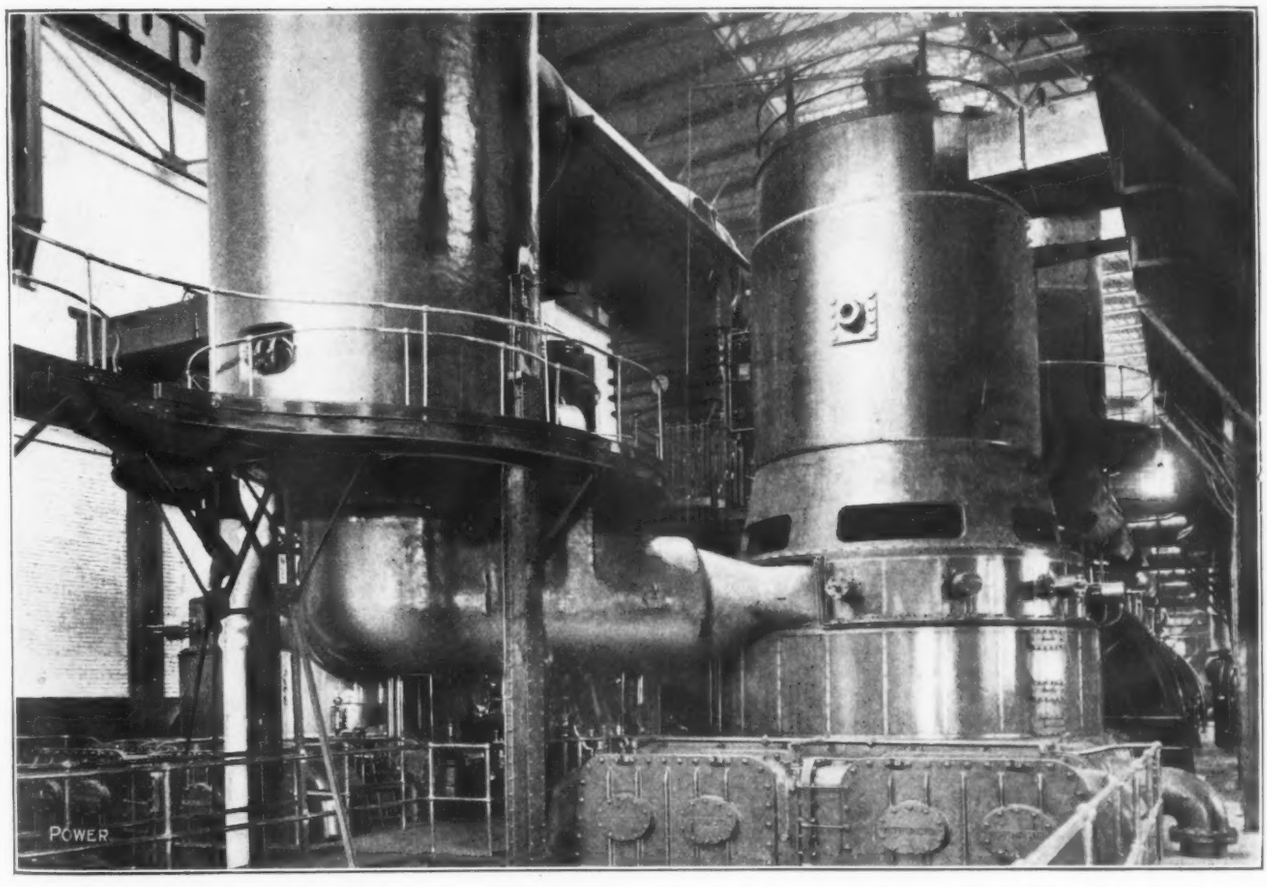


FIG. 2. LOW-PRESSURE TURBINE WITH RECEIVER, SEPARATOR IN FOREGROUND

TURBINE CONTROL BOARDS AND SPECIAL GOVERNORS

Fig. 7 shows the control board on one of the low-pressure turbines; similar boards are set upon the other machines and duplicates of each are mounted on the switchboard. The instruments at the top of the board consist of a speed indicator and wattmeter and gages showing the steam pressure, vacuum and step-bearing oil pressure. These, together with a synchroscope mounted nearby, afford the engineer all the necessary information for starting and synchronizing the machine. For communication between the engineer and the switchboard operator, an electric signaling device is used. On the board are six illuminated signals: "On," "Off," "Hold," "Increase," "Decrease" and "Off Quick." Duplicates of these are on the switchboard, and by their use all necessary communication can be quickly obtained.

The combination of three engines driving 25-cycle alternators and four driving 600-volt railway generators exhausting into 25-cycle low-pressure turbo-generators at first gave trouble in keeping the exhaust pressure constant. As the load on the engines would increase, the turbine would tend to speed up, but the speed governor on the latter unit would partly close the butterfly valve in the steam intake. The exhaust pressure would consequently rise until the relief valve opened and allowed some steam to exhaust to the atmosphere. On account of the constant fluctuations of load on the railway engines and the variations being different from those on the 25-cycle system, this condition would occur frequently. To prevent it, an additional governor was designed and put on each of the two turbines. A steam piston within a cylinder and operated by the rise and fall of the exhaust pressure was arranged to work a set

of valves which controlled by compressed air four of the nozzle valves on the turbine, the other four valves being operated by hand as before.

The arrangement is shown quite clearly in Fig. 7, the governing mechanism being on the left and the hand-operated valves on the right. If the load on the engines increases, raising the exhaust pressure, the cylinder moves the rack-and-pinion combination, so placing the air valves that the nozzle valves are opened, admitting more steam to the turbine and lowering the pressure. The speed governor is set one cycle high, so as not to interfere with the operation of the other governor. This system has proved successful, and the exhaust pressure is always kept close to the 16 lb. per sq.in. that is needed for the best operation of the turbines.

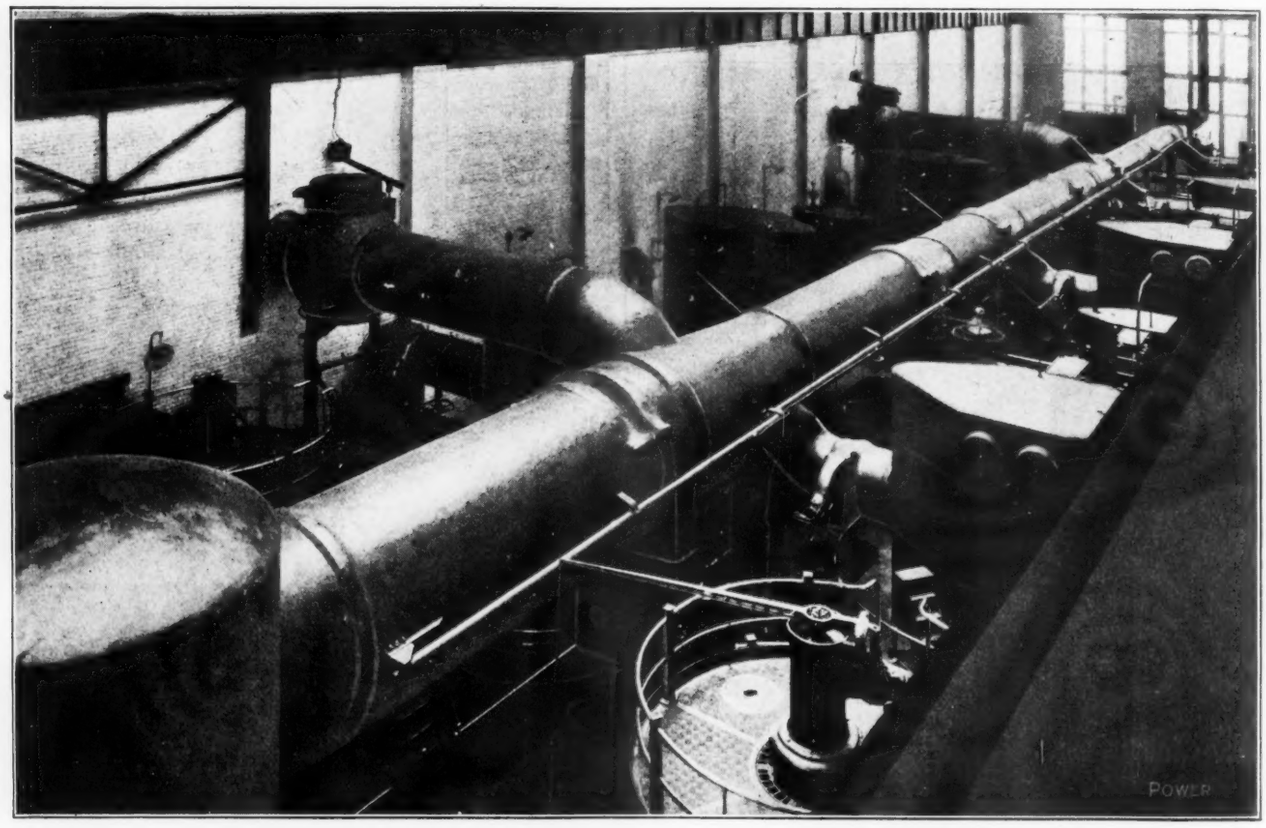


FIG. 3. VIEW OF EXHAUST HEADER FROM ENGINES TO L. P. TURBINE

VACUUM MEASURED BY THERMOMETERS

On the turbines the method of measuring the vacuum is unusual. Instead of the familiar recording vacuum gage, a thermometer is used, with the thermometer element placed in the path of the steam directly below the last wheel of the turbine. The charts used can be read either in degrees or in inches of vacuum corresponding to that temperature. This method has worked out well, as it not only gives accurate results, but also shows the back pressure without making corrections for barometric conditions.

CONDENSING EQUIPMENT

From the plan and sectional view of the north end, the general layout of the condensing apparatus can be seen. Cooling water is received from an intake tunnel tapping the river directly north of the station. A revolving, motor-driven screen just inside the station removes all the solid particles not taken care of by the wide-mesh screen at the mouth of the tunnel. The surface condensers are of the base type, with 25,000 sq.ft. of cooling surface, and the four sets of equipment are identical. A 36-in. centrifugal pump driven by a corliss engine supplies the cooling water, and a 31x24-in. air pump, in tandem with the engine cylinder, takes care of the air collecting in the condenser. The condensed steam is removed by a 5-in., two-stage centrifugal pump, which elevates the water into large storage tanks. Each pump is driven by a 24-hp. horizontal steam turbine or a 25-hp. induction motor. Usually, the motor does not furnish any power, but is kept floating on the line ready to pick up the load in case of trouble with the turbine. Two 4000-sq.ft. surface condensers, two 14-in. centrifugal, motor-driven circulating pumps, two vertical engine-driven air pumps, and one 3-in., two-stage motor-and-turbine-driven hotwell pump comprise the condensing equipment for the 4500-kw. turbine. The reason for this unusual arrangement of two condensers on one turbine was due to the dismantling of the two 1000-kw. turbines. The condensers and pumps were still in good condition and were made use of in this way. The barometric condenser on engine No. 1, which can be seen in the general layout, is fitted with a 10-in. motor-driven centrifugal pump and an engine-driven air pump.

EXCITERS

Four 75-kw., 125-volt exciters furnish the direct current for excitation in the station, three being near the

large turbines and one beside the engine-driven alternators. All connect to the same busbar and are driven by horizontal turbines, operating noncondensing. In addition, a storage battery is kept on the bus at all times for reserve. Direct current can also be obtained from a downtown station or from the 400-kw. engine-driven set, so that the danger of any interruption to excitation is remote.

Boiler Room

Installed in the boiler room are 24 water-tube boilers, eight being of 650-hp. each, eight of 708-hp. each, and the remaining eight of 765-hp. each. The total capacity of 16,984 hp. gives 3.64 kw. installed capacity for each rated boiler horsepower installed, although in operation the ratio is about 1½ to 1, installed capacity. As indicated in Fig. 8, each battery of two boilers is equipped with its own steel self-supporting stack, 8 ft. in diameter and 100 ft. high. Sixteen are fired by underfeed stokers, with automatic attachments; seven with gravity underfeed stokers (see Fig. 9), and one with a self-cleaning underfeed stoker. The forced draft necessary is supplied by fans in the pump room directly below the boilers. The coal burned is Youghiogheny screenings and is stored in bunkers running the entire length of the station immediately above the aisle between the rows of boilers, coal chutes running down to each stoker.

Superheaters, consisting of several rows of tubes above the drums, are on all the boilers and raise the temperature of the steam about 40 deg. Eight boilers, the 765-hp. units, are equipped with additional superheaters, which raise the superheat to about 150 deg. As most of the steam from the large boilers is used in the high-pressure turbines, high superheat is desirable, but the lower superheat from the other boilers is sufficient for the engines.

Each boiler is equipped with an indicating steam-flow meter, mounted where it may be seen readily by the firemen, and with the target set at the most economical boiler rating as determined by tests. An illuminated differential draft gage showing the draft over the fire is placed on the side of each boiler close to the stack damper regulator, to facilitate keeping the furnace draft at the correct pressure. An illuminated gage is also provided for the air pressure in the wind box beneath the fire, and the air damper regulator placed close at hand so that the forced draft can be kept at the most efficient point.

Besides the two regular feed lines to each boiler, there is a connection to a test line running the entire length of the boiler room, making it possible to isolate any boiler or boilers for testing purposes. Feed-water regulators are placed on the feed lines to each boiler, and an injector for emergency use is also installed for each unit.

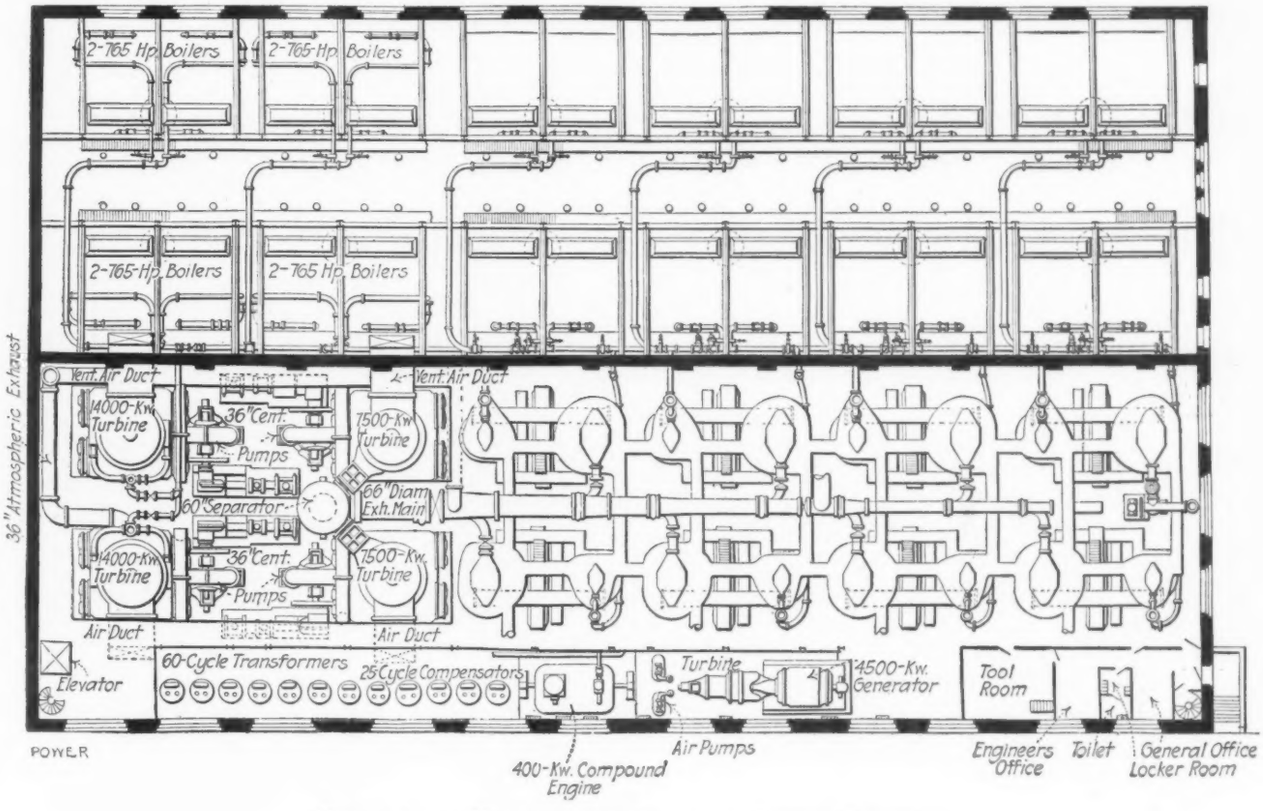


Fig. 4. Plan View of the Commerce Street Station

The boiler-room piping is so arranged that the boilers can either furnish steam to the engines or turbines or into the subheader, which is the stretch of 10- and 12-in. piping running the entire length of the plant. All subheader piping is of steel, with cast or ferrosteel fittings, as is also the piping in the north end and to the turbines. A 5-in. auxiliary steam header runs through the pump room, supplying steam for the feed pumps and turbines there. Steam for the turbine auxiliaries is taken directly from the turbine headers. The 4500-kw. turbine and the 400-kw. engine and auxiliaries, together with the low-pressure turbine auxiliaries, are fed from a steam

line in the form of a loop, tying into the subheader in two places. All boiler, subheader and header tie valves are motor driven, the control cabinets being on the engine-room side of the division wall.

Smoke Inspection

On the edge of the roof and affording a full view of the tops of all the stacks, is the smoke observer's shanty. A system of electric signaling devices connects the shanty with the boiler room, so that when the observer notices a stack smoking, he turns on a switch, causing a bell to ring and a light to burn down in the boiler room near the battery making the smoke. The firemen can readily tell what boiler or boilers are producing smoke, and to let the smoke observer know his signal has been understood, the bell is turned off. The light, however, can be turned off only from the roof, and remains lighted until the stack stops smoking. In addition to tending these signals, the smoke observer keeps a record of the time each stack smokes and the quality, so that at the end of the day's run the superintendent knows just how his station has performed in this regard. This report, along with all other station records, is sent to the office of the chief engineer of power plants each morning and forms a valuable adjunct in coöperating with the smoke-abatement work carried on by the city.

Pump Room

The pump room is directly beneath the boiler room, and in it are the feed-water heaters, the feed pumps, boiler fans, house pumps and other miscellaneous equipment. There are six feed-water heaters of the open horizontal type, four in the south end of the station and two in the new addition. The supply of feed water is obtained from the storage tanks fed by the hot-well pumps on the turbines. The water is pumped from these tanks to the heaters by a 10-in., motor-driven, centrifugal pump and by an 8-in., double-suction pump driven by a 40-hp. turbine. Six pumps deliver the water to the boilers, four being 18 and 10 by 18-in. duplex, outside-packed, pot-type pumps, and two 14x26 and 8x 24-in. cross-compound, engine-driven, outside-packed, pot-type pumps. Two of the smaller pumps are used for the high-pressure water supply, only one being kept running continuously. This water is used for wetting down ashes, cleaning boilers and for all purposes where high-pressure water is needed.

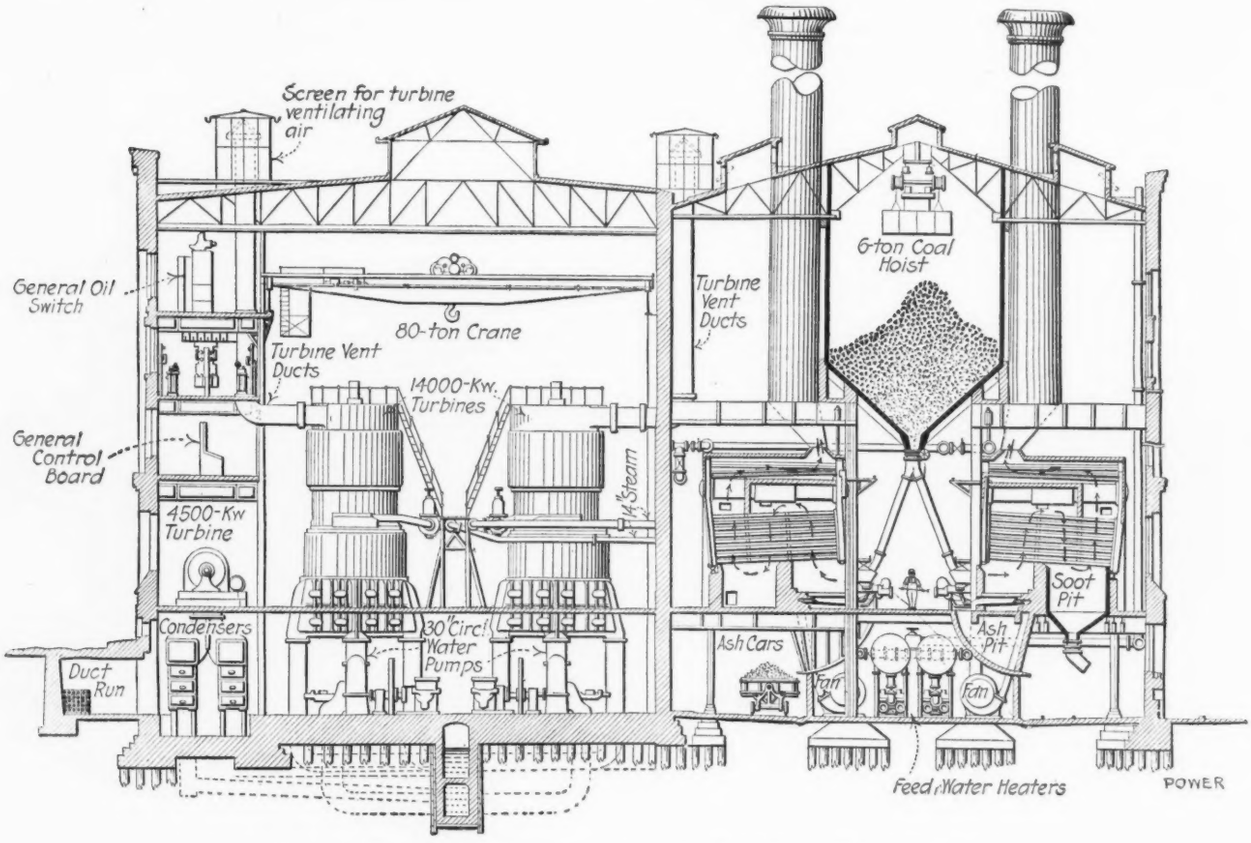


Fig. 5. Sectional Elevation of the Commerce Street Station

Four 4-in. motor-driven, centrifugal pumps furnish the low-pressure water which is used in the cooling jackets of the air pumps and as make-up water for the storage tanks. Both high- and low-pressure pumps take their water from the discharge tunnel for the circulating pumps, and there is a connection between the two systems for emergency in case of any failure of the motor-driven pumps. High-pressure water can be fed into the low-pressure line through proper reducing valves. In the pump room are also the fans for the boiler forced draft. Those for the 650-hp. boilers in the south end are driven by 24-hp. induction motors, those for the 708-hp. boilers by 25-hp., 600-volt, direct-current motors, while the 765-hp. boilers each have two blowers driven by a 60-hp., 5-stage horizontal turbine, which also furnishes the power for driving the gravity underfeed stokers. The testing equipment, described later, and the two motor-

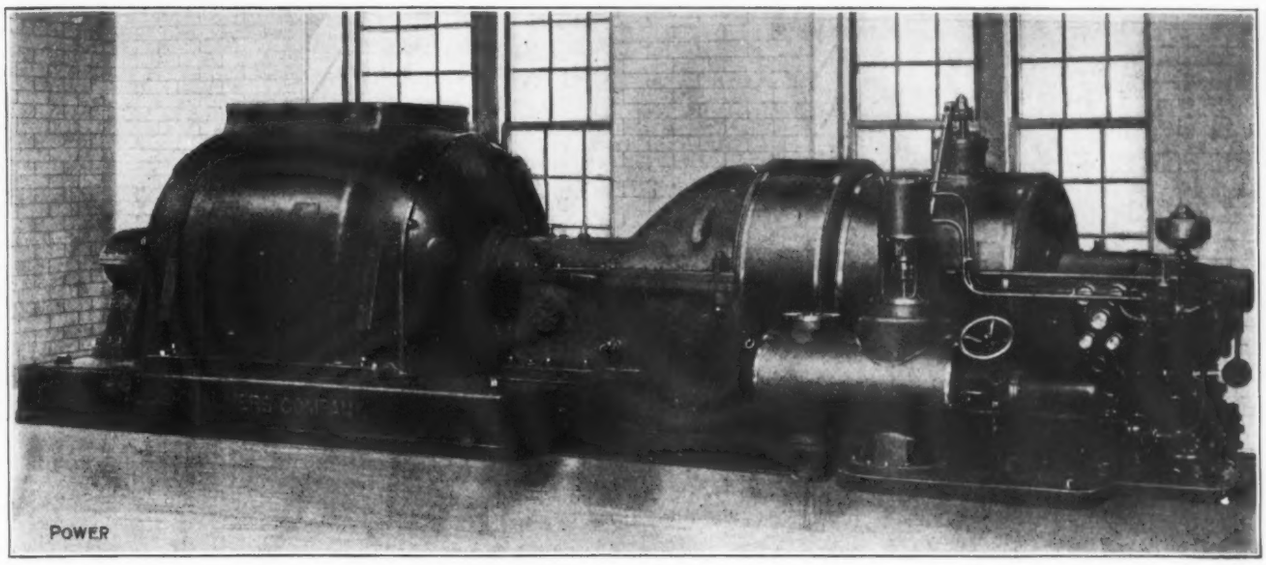


FIG. 6. VIEW OF 4500-KW. TURBINE

driven and one steam-driven air compressors are also in the pump room.

COAL AND ASH HANDLING

Coal is received by boat from a nearby fuel company, the boat being fitted with a belt conveyor and also supplying the downtown station. Because of the large amount stored at the company's yards, it is not necessary to keep any great supply at the station, as, in case of any trouble with the water route, coal can still be received in wagons. Consequently, the only storage is in the bunker over the center of the boiler room between the rows of stacks. This bunker holds about 2000 tons, or three days' supply.

The coal from the boat is discharged into a 15-ton hopper at the north end of the station, equipped with an automatic slide door and chute, and is fed from there into an 8-ton iron coal box resting on a 20-ton platform scale. The coal is weighed and hoisted to the top of the building by the crane suspended on a track over the bunkers. This permits the crane operator to dump the coal at any point along the bunker. One man is needed on the crane and one at the scale.

There are one 6- and one 5-ton single-track cranes at the south end of the building, together with a 20-ton platform scale and several coal boxes. These were used to unload the coal from wagons when that method was employed, and are now used as reserves.

The removal of the ashes from the hoppers to the cars is a simple process. The general layout of the hoppers

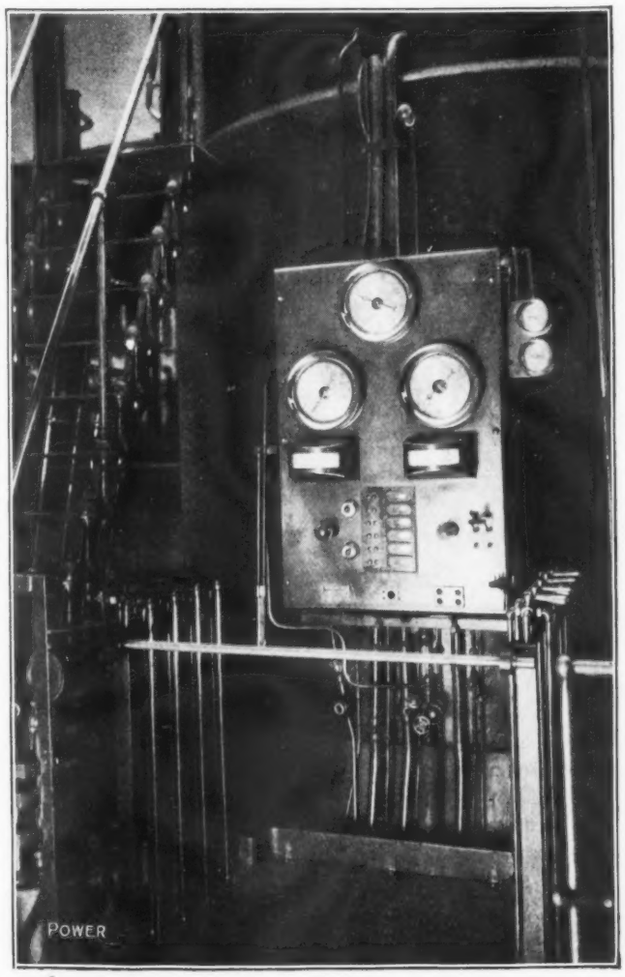


FIG. 7. CONTROL BOARD ON LOW-PRESSURE TURBINE; ALSO AIR VALVES AND MECHANISM ON GOVERNOR

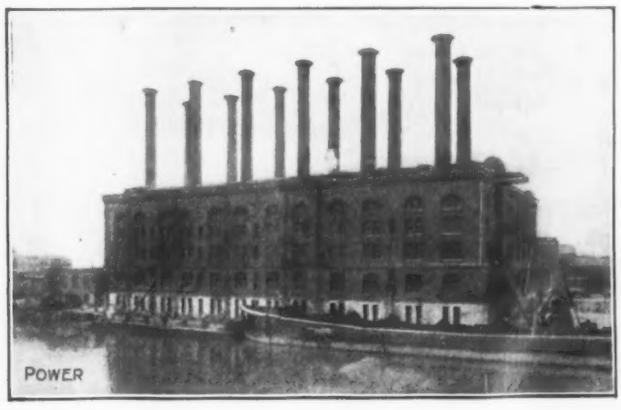


FIG. 8. THE COMMERCE ST. STATION AS SEEN FROM THE RIVER

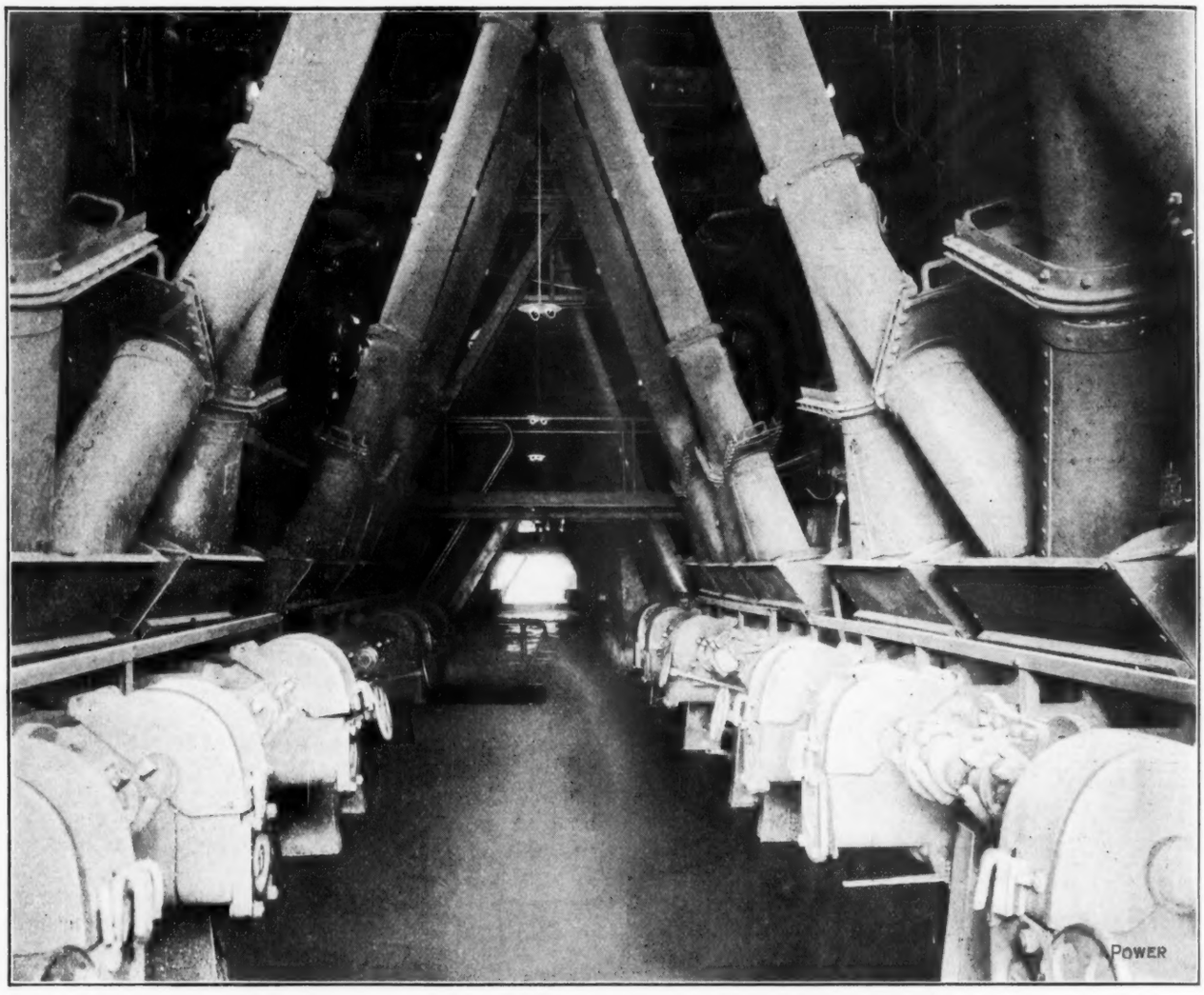


FIG. 9. NORTH END OF BOILER ROOM, SHOWING TAYLOR STOKERS

is shown in the cross-sectional view of the station, and it is clear that the ash cars can be placed beneath each hopper. At various points in the hopper there are jet nozzles, and when the air-operated doors are opened, the water is turned on and the ashes flushed out into the cars. All but the largest clinkers are removed by this process; these are pulled out with an ash hoe. Tracks run the entire length of both ash alleys, and a storage-battery locomotive, hauling three cars at a time, furnishes the necessary motive power. At the north and south ends of the east alley are two conveyors into which the ashes can be dumped. These carry the ashes out into a scow in the river which is towed out on Lake Michigan and dumped.

TESTING EQUIPMENT

A separate feed line runs to each boiler and connects with a 10 and 5 by 12-in. duplex feed pump in the north end of the pump room. This pump takes its supply from a large storage tank sunk below the basement floor immediately beside it. Above the tank is a 2500-lb. automatic dumping scale which weighs all the water fed into the tank. The arrangement is compact and one man can operate the scale and pump and take all the necessary readings. This outfit can also be used for turbine tests, as the discharge of any of the hot-well pumps can be changed to feed into the tank through the scale. A 5-in., motor-driven centrifugal pump is provided to empty the tank in a test of this nature. The testing equipment on the boilers is complete, thermometer wells being placed wherever necessary and piping run to various parts of the setting to permit CO_2 and draft readings to be quickly taken.

FIG. 10. BONUS BOARD, BOILER HORSEPOWER METER AND MASTER STEAM GAGE

In the southwest corner of the basement is a machine shop, in which are all the machines needed for the work that constantly arises in a plant of this size. All but the largest jobs can be done here, and with the modern equipment a considerable saving is effected over the cost of outside work. A waste-washing outfit is also in the basement, where a large amount of oil, suitable for further use after proper treatment, is extracted from the waste and rags. Directly beneath the entrance are shower baths and lockers for the men. The superintendent and his assistants have offices at the entrance to the building in the southwest corner, where all the charts and records are brought before being sent to the main offices. There is a completely stocked store and tool room beside the offices, where most of the supplies are kept.

PRINCIPAL EQUIPMENT OF THE COMMERCE ST. STATION
MILWAUKEE ELECTRIC RAILWAY AND LIGHT CO.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Turbines	Vertical Curtis six-stage	14,000 kw.	Main units	180 lb. steam, 720 r.p.m., 4000 v., 3-phase, 60-cycle	General Electric Co.
2	Turbines	Vertical Curtis four-stage	7500 kw.	Main units	Low pressure, 750 r.p.m., 6600 v., 3-phase, 25-cycle	General Electric Co.
1	Turbine	Horizontal parsons	4500 kw.	Main units	180 lb. steam, 1800 r.p.m., 1000 v., 3-phase, 60-cycle	Allis-Chalmers Co.
4	Engines	Vertical cross-comp.	2000 kw., 32x68x48 in.	Main units	180 lb. steam, noncondensing, 600 v., direct connected	Allis engines Gen. Elec. Generators.
3	Engines	Vertical cross-comp.	1500 kw., 28x60x48 in.	Main units	180 lb. steam, noncondensing, 13,200 v., 3-phase, 25-cycle	Allis engines, Gen. Elec. generators
1	Engine	Vertical cross-comp.	1500 kw., 28x60x48 in.	Main units	180 lb. steam, condensing, 13,200 v., 3-phase, 25-cycle	Allis engines, Gen. Elec. generators
1	Engine	Vertical cross-comp.	400 kw., 18x36x30-in.	Station auxiliary power	180 lb. steam, noncondensing, driving two 200 kw., 125 v., d.c. gen.	Allis engines, Gen Elec. generator
4	Turbines	Horizontal Curtis	75 kw.	Exciters	180 lb. steam, connected to 125 v., d.c. gen., r.p.m.	General Electric
4	Condensers	Surface	25,000 sq.ft.	14,000 and 7500 kw. turbines		H. R. Worthington
2	Condensers	Surface	4000 sq.ft.	4500 kw. turbine		F. M. Prescott Steam Pump Co.
1	Condenser	Barometric	2500 hp.	1500 kw engine		H. R. Worthington
4	Pumps	Centrifugal	36-in , 30,000 g.p.m.	Circulating pumps	Each driven by Laidlow-Dunn-Gordon Corliss engine, noncondensing	H. R. Worthington
2	Pumps	Centrifugal	12-in., 4200 g.p.m.	Circulating pumps for 4500 kw. turbine	Each driven by 30 hp., 60-cycle, 220 v., ind. motor	Lawrence Machine Co.
1	Pump	Centrifugal	10-in., 2000 g.p.m.	1500 kw. engine	Driven by 50 hp. ind. motor	H. R. Wortaington
4	Pumps	Dry vacuum	31x24-in.	14,000 and 7500 kw. turbines	In tandem with above engines driving circ. pumps	Laidlow-Dunn-Gordon Co.
2	Pumps	Dry vacuum	10x18x16-in.	4500 kw. turbine.	Engine driven, vertical	F. M. Prescott Steam Pump Co.
1	Pump	Dry vacuum	8x16x12-in.	1500 kw. engine.	Engine driven, vertical	H. R. Worthington
4	Pumps	Centrifugal wet vacuum	3-in. two-stage, 600 g.p.m.	Hotwell pump for 14,000 and 7500 kw. turbines	Each driven by 25 hp. ind. motor and 24 hp. Curtis horizontal turbine	H. R. Worthigton
1	Pump	Centrifugal	3-in. two-stage, 200 g.p.m.	Hotwell pump for 4500 tur.	Driven by 15 hp. ind. motor and 11 hp. Kerr turbine	H. R. Worthington
4	Pumps	Duplex	12x3x18-in.	Step bearing on vertical tur.	Steam driven	H. R. Worthington
4	Pumps	Duplex	9x5¼x10-in.	Oil for vertical turbines	Provided with 2-in. Elliott strainers	Blake & Knowles Steam Pump Works
7	Pump	Duplex	3½x2x3-in.	Oil for engines		F. M. Prescott Steam Pump Co.
1	Pump	Centrifugal	1½-in., 55 g.p.m.	Discharge of trap lines to storage tank	Driven by 10 hp. ind. motor	Lawrence Machine Co.
1	Pump	Centrifugal	1¼-in., 55 g.p.m.	Cooling water for step bearing oil tanks	Driven by 5 hp. ind. motor	Lawrence Machine Co.
8	Boilers	Water-tube	650 hp.	Generate steam.	180 lb. pressure, 40 deg. superheat, stoker fired, forced draft	Edge Moor Iron Co.
8	Boilers	Water-tube	708 hp.	Generate steam.	180 lb. pressure, 40 deg. superheat, stoker fired, forced draft	Edge Moor Iron Co.
8	Boilers	Water-tube	765 hp.	Generate steam.	180 lb. pressure, 150 deg. superheat, stoker fired, forced draft	Edge Moor Iron Co.
24	Superheaters	Edge Moor		On all boilers	40 deg. superheat	Edge Moor Iron Co.
8	Superheaters	Foster	44 elements	On 765 hp. boilers	150 deg. superheat	Power Specialty Co.
16	Stokers	Jones under-feed		On 650 nd 708 hp. boilers	Operated by Cole automatics	Under-feed Stoker Co. of America
1	Stoker	Jones under-feed self-cleaning		On one 765 hp. boiler	Operated by Cole automatics	Under-Feed Stoker Co. of Am.
7	Stokers	Taylor under-feed		On seven 765 hp. boilers	Driven from fan shaft in basement	American Engineering Co.
8	Fans	National		Forced draft for 650 hp. boilers	Driven by 20 hp. ind. motors	National Blower Co.
8	Fans	Bayley		Forced draft for 708 hp. boilers	Driven by 25 hp., 600 v., d.c. motors	Wm. Bayley & Sons
16	Fans	A.B.C. Sirroco		Forced draft for 765 hp. boilers	Each set of two driven by 60 hp. 5-stage hor. Kerr turbine	American Blower Co.
24	Steam flow meters	G. E. indicating, type F. S.-2		On all boilers		General Electric Co.
2	Feed water heaters	Open	5000 hp.	Heat feed water.	Exhaust steam	Hoppes Mfg. Co.
4	Feed water heaters	Open	1500 hp.	Heat feed water.	Exhaust steam	Hoppes Mfg. Co.
2	Pumps	Outside packed, pot type	14x26x8x24-in. 1000 g.p.m.	Boiler feed	Cross comp. eng. driven	F. M. Prescott Steam Pump Co.
4	Pumps	Duplex	18x10x18-in., 400 g.p.m.	Boiler feed	Steam driven	F. M. Prescott Steam Pump Co.
1	Pump	Duplex	10x5x12-in., 120 r.p.m.	Boiler testing	Steam driven	F. M. Prescott Steam Pump Co.
1	Pump	Centrifugal	10-in., 2000 g.p.m.	Feed water from tanks to heater	Driven by 50 hp. ind. motor	H. R. Worthington
1	Pump	Centrifugal	8-in., 1650 g.p.m.	Feed water from tanks to heater	Double suction volute, driven by 40 hp. Terry turbine	H. R. Worthington
1	Pump	Centrifugal	5-in., 734 g.p.m.	Test tank	Driven by 10 hp. ind. motor	Lawrence Machine Co.
2	Pumps	Centrifugal	4-in., 430 g.p.m.	Low pressure water supply	Driven by 10 hp. ind. motor	H. R. Worthington
2	Pumps	Centrifugal	4-in., 430 g.p.m.	Low pressure water supply	Driven by 15 hp., 600 v., d.c. motor	Lawrence Machine Co.
1	Crane	Double track	16,000 lb.	Hoisting coal	Motor operated	Pawling & Harnischfeger Co.
1	Crane	Single track	12,000 lb.	Hoisting coal	Motor operated	Pawling & Harnischfeger Co.
1	Crane	Single track	10,000 lb.	Hoisting coal	Motor operated	Pawling & Harnischfeger Co.
2	Scales	Howe platform	40,000 lb.	Weighing coal	Equipped with self registering beam	Howe Scale Co.
2	Conveyors	Bucket	31 buckets	Handling ashes	Enclosed casing, operated by 10 hp. motor	Chain Belt Co.
1	Scale	Automatic	2500 lb.	Testing	Avery water weighing scale	Avery Scale Co.
1	Crane	Traveling	80-ton	Engine room	Motor operated	Toledo Bridge & Crane Co.
1	Crane	Traveling	30-ton	Engine room	Motor operated	Pawling & Harnischfeger Co.
1	Crane	Traveling	6-ton	Engine room	Motor operated	Pawling & Harnischfeger Co.

Bonus System

Perhaps the most interesting feature of the entire station is the system of bonus payment for the men, which enables them to receive a share of the profits accruing from economical and efficient operation. After careful investigation, the engineers of the company decided upon a certain B.t.u. standard per switchboard kilowatt-hour that could be expected from good operation obtained by careful attention to duty by all the men. Any saving below this figure can be figured back into dollars and cents, and a certain percentage divided among the men, those participating being men whose work bears directly on operation, as engineers, oilers, boiler-room foremen, firemen, coal passers, switchboard operators, attendants, etc. All smoke fines are deducted from the total bonus due the men in the month that the fine is made.

The bonus is expressed in percentage of the men's wages, which means that a fireman earning about $75 per month, in a month when a 5 per cent. bonus is made, receives a check for $3.75 in addition to his regular wage. To keep up interest, what is known as the "bonus board" is set up in the boiler room, as shown in Fig. 10. The results each week are figured out and the percentage bonus, based on an average weekly pay roll, is posted. From this the men can tell whether they did well the past week, and if they see a loss they can look for the cause and remedy it. The results of this system have been readily apparent since its adoption almost ten months ago. Each man has tried his best to follow out his instructions, as he realizes that they tend toward more economical operation, and consequently a larger bonus check at the end of the month.

Beside the bonus board is an illuminated master steam gage, a recording steam gage and a boiler-horsepower meter. The latter is simply a wattmeter calibrated to read in boiler horsepower in accordance with the kilowatt-hour per boiler-horsepower standard. This serves as a guide to the firemen as to the number of boilers to be kept on the header, so that the pressure may be kept constant and each boiler at its most economical rating.

John Anderson is chief engineer of power plants for the company and Fred Dornbrook is in charge of the operation of the Commerce St. plant. To the former we are indebted for the information contained in this article.

Uehling Barometer and Vacuum Recorder

One of the most important factors in the economy of steam consumption for power purposes is the absolute back pressure. To reduce this pressure to a minimum is the office of the condenser, and it is, therefore, most desirable to keep close tabs on the condenser. Vacuum gages and recorders are used for this purpose.

Ordinary vacuum gages and recorders, however, do not indicate or record the back pressure directly or correctly. The vacuum as recorded varies with the barometer at the time and place, whereas the absolute back pressure in the condenser is independent of the barometric pressure, but is always equal to the difference between the two. The nearer the vacuum approaches the barometer, the lower the back pressure, and *vice versa*.

The Uehling Instrument Co., Passaic, N. J., has put on the market a combined barometer and vacuum recorder which puts these two records in juxtaposition on the same chart. Using the barometer record as the base line, the absolute back pressure can be correctly read off directly from the chart. The instrument is shown herewith.

It consists of two float chambers, one connected with a barometric mercury column, the other with a mercury

Uehling Barometer and Vacuum Recorder

column in communication with the condenser. These columns and double float chambers are secured to the case of the recorder. The pens are actuated by the floats and move in harmony with the barometric pressure and the vacuum.

Combustion—By combustion is meant the chemical union of the combustible material of a fuel and the oxygen of the air. The fireman is the manufacturing chemist. Theoretically the process is a simple one as it is only necessary to bring the fuel at kindling temperature in contact with the correct amount of oxygen and combustion will be complete. In practice, however, the size and character of fuel and its impurities, type of furnace, draft, mechanical and human difficulties enter in, causing the combustion to become less perfect and the fireman becomes less of a chemist and more of a coal heaver.

Short-Circuits and Grounds in Field Coils

By F. A. Annett

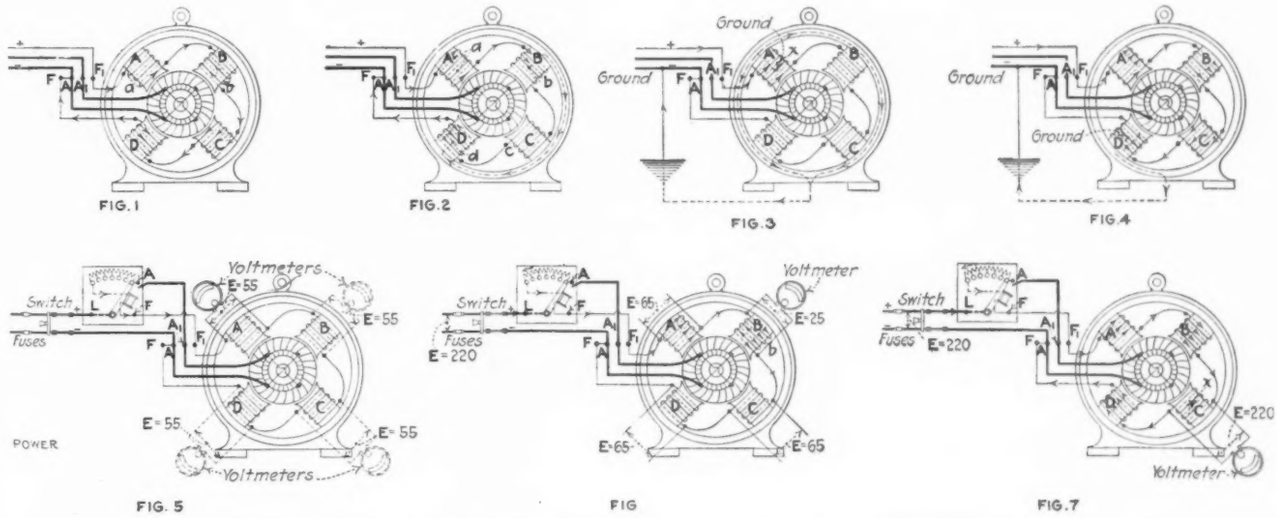
SYNOPSIS—The causes and effects of short-circuits and grounds in field coils and how to locate them by means of a lamp or voltmeter.

Short-circuits in the field coils of a motor or generator may be caused in several ways: First, if the two terminals of the coil come in contact with one another, as at *a*, Fig. 1; this would completely short-circuit the coil, consequently, no current would pass through the winding of coil *A*. Second, a partial short-circuit of the winding, as at *b*, Fig. 1, is caused by the insulation breaking down between two turns in different parts of the coil. One of the chief causes of this is, when the coil is being taped the outside end turns are sometimes allowed to become misplaced and fall in upon the end of the coil after reaching the inner layers; high voltages exist between these outside and inner turns, and if the field circuit is opened suddenly the induced voltage may be high enough to break down the insulation. Third, moisture in the field coils will cause short-circuits, or grounds. A fourth cause of partial short-circuits is grounds under various conditions, some of which are two grounds in the same field coil, as at *a*, Fig. 2, which will cause a partial short-circuit of coil *A*. This has the same effect as that shown at *b*, Fig. 1.

Again there may be a ground in two different coils, as at *b* and *d*, Fig. 2; this short-circuits part of coils *B* and *D* and cuts out coil *C* entirely as indicated by the dotted lines which show the path the current will take. If the frame of the machine and one side of the line is grounded, one ground in the field coil will short-circuit one or more coils depending upon which is grounded. For instance, referring to Fig. 3, if coil *A* is grounded to the core, current can flow from the positive side of the line to the field terminal F_1 through part of field coil *A* to the frame of the machine, then to the ground and back to the negative side of the line as indicated by the dotted lines and arrowheads. A condition like this would cause the fuses to blow or the circuit-breaker to open with very bad heating or a complete burn-out of the grounded coil. On the other hand, if the ground is in coil *D*, as in Fig. 4, only part of coil *D* would be short-circuited, the current flowing as indicated, and the effect would be that of a partial short-circuit such as at *b*, Fig. 1. One ground in the field coil where everything else is insulated from ground will not have any effect upon the operation of the machine.

A ground in the field winding, combined with a ground in the armature, or the controlling device, may produce several effects, depending upon the conditions under which it occurs therefore, in case of trouble on a machine one of the first things is to test the various parts for grounds.

A short-circuit in one of the field coils of a two-pole motor will not have any effect upon its operation other than cause a slight increase in speed. However, the temperature of the two coils will be different depending upon how much of the defective coil is short-circuited. The heating in the good coil may become excessive and it will be burned out unless the defective coil is repaired. With any other number of poles, if one coil is short-circuited, the machine will start up with a good effort but will spark and burn badly at the brushes and if the starting resistance is cut out the fuses will blow.



Methods of Locating Short-Circuits and Open Circuits

Locating Short-Circuits

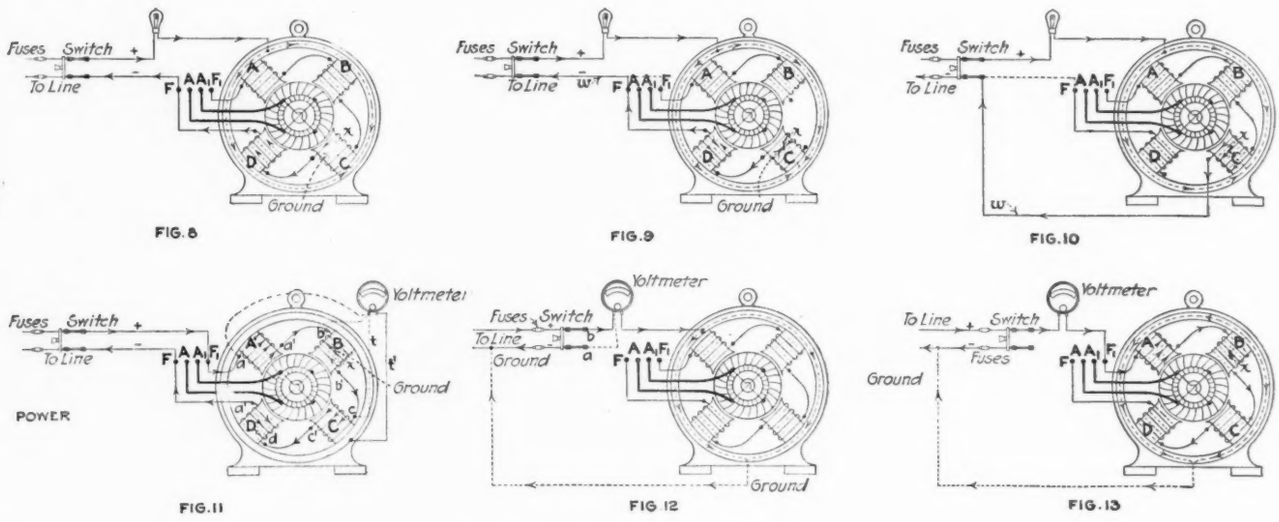
One method of locating a short-circuited coil is: First, connect the coils to the line or, if the machine is already connected, disconnect the armature lead at the starting box, close the switch, and move the starting-box arm over to the running position as in Fig. 5. After the field coils have been connected to the line for

15 or 20 minutes the defective coil may be located by noting the comparative temperatures of the different coils with the hand; the defective coil will be much cooler than the others.

A better method of testing for short-circuits is to use a voltmeter for measuring the drop across each coil as indicated in Fig. 5. If none of the coils is defective the voltmeter reading across each coil will be equal to the line voltage divided by the number of coils. For instance, the drop across each coil of a four-pole machine connected to a 220-volt circuit should equal $220 \div 4 = 55$ volts. If one coil is short-circuited the voltage drop across the defective coil will be less than that across the others, producing a condition similar to that in Fig. 6, which shows coil *B* short-circuited at *b*, therefore, the voltage drop across it will be less than across the other coils which, in this case is assumed to be 65 volts as indicated, while across the defective coil the voltmeter reading is only 25 volts. If the coil were completely short-circuited, as at *a*, Fig. 1, the voltmeter if it is still found to be defective the only remedy is rewinding.

Testing for Grounds

To test the field coils for a ground a lamp may be used, as shown in Fig. 8. With the machine otherwise disconnected from the line, connect one side of the line to one terminal of the field coils then connect the lamp from the other side of the line to the frame of the machine. If one of the coils is grounded to the frame as at *x* the lamp will light. The particular coil that is grounded may be located as follows: Open a connection between the coils so as to divide them in two equal groups as in Fig. 9 and test each group separately for grounds which in this case would be found to be in the group containing coils *C* and *D*. After the group with the ground has been located, open the connection between each individual coil in this group and test each coil for a ground, as indicated in Fig. 10, which in this case would be found in coil *C*.



Methods of Locating Grounds

when connected across its terminals would read zero and indicate one-third line voltage across the terminals of the other three coils.

Open-circuited coils can be located in the same way, as indicated in Fig. 7. When the voltmeter is connected across the terminals of coil *C*, which is shown open circuited at *x*, it will read the line voltage, for it completes the circuit through the other three coils. If it is connected across the terminals of any one of the other three coils it will read zero.

Instead of using a voltmeter to locate the short-circuited coil a lamp may be employed, although not with the same degree of satisfaction as with the voltmeter. When the lamp is used the defective coil will be indicated by the lamp glowing dimmer when connected to its terminals than when connected to the other coils.

If the field coils are not wound on spools the short-circuit is usually easily located and repaired. After the tape has been removed from the coil, if the short-circuit cannot be located, it is well to connect the coil again and make another test to make sure that the short-circuit has not been removed in some way in removing the tape.

A ground in the field coil may also be located by means of a voltmeter, as in Fig. 11. Connect the coils to the line, then connect one terminal of the voltmeter to the frame of the machine and with the other test the different coil terminals and note the readings. For instance, consider a condition as shown, where coil *B* is grounded at *x*. If the voltmeter is connected to coil terminal *a* it will read the voltage drop across coil *A* and part of coil *B*, the latter depending on how near the ground is to *b* or b^1. If the voltmeter is now connected to *b* it will read less than one-fourth the line voltage, and if connected to *c* it will again read less than the line voltage divided by the number of coils which indicates that the ground is in coil *B*. This may then be disconnected and tested separately with a lamp, or voltmeter as described for Fig. 10.*

If one side of the line and the frame of the machine is grounded, as in Figs. 3 and 4, the method of testing the field coils for grounds would be practically the same

*If the voltmeter will read direct current only, connections t and t' will have to be interchanged before the instrument will read when connected to c.

as previously described. However, the first thing is to find the side of the line that is not grounded. This can be done as shown in Fig. 12. With the machine disconnected from the line, connect one side of the test lamp or voltmeter to the frame of the machine and with the other connect first to one side of the line and then to the other until the lamp lights or the voltmeter indicates. In this instance if the testing device is connected to *a* it will not indicate, but will indicate when connected to terminal *b*, the path of the current being indicated by the dotted lines and arrowheads.

After this has been determined the field coils may be tested for grounds by disconnecting the testing device from the frame of the machine and connecting it to one of the field terminals, as in Fig. 13, in which coil *B* is grounded at *x*. If no coils were grounded the testing device would not indicate. The grounded coil may then be located in the manner described for Figs. 9 and 10, or a voltmeter may be used in which case the wire *w* (Figs. 9 and 10) is dispensed with and the voltmeter lead is brought direct to one of the coil terminals as shown in Fig. 13.

Plants of Interest in Milwaukee

By Thomas Wilson

SYNOPSIS—An unusually well illustrated article treating of features of plants in busy Milwaukee. An old Corliss engine installed in 1881 and giving service every day is described. The coal-handling plant for the Schlitz breweries is worthy of note.

Of the manufacturing cities in this country, Milwaukee ranks as one of the foremost. It has a varied line of staple products, many of which are intended for use in the power plant. The city is one of the greatest coal distributing points on the Upper Lakes and its bank clearings are not far behind those of the great industrial centers. So much manufacture naturally requires a great deal of power, and, as might be expected, Milwaukee has a number of interesting plants; some are private installations, others belong to the three central-station companies, and in the breweries there are immense refrigerating plants which are worth investigating. It is the purpose of this article to enumerate the features of some of the leading plants, those that would be worth a visit while at the convention. Two of the large ones have been given space in this issue, and with those mentioned hereinafter there will be variety from which to choose.

Pfister & Vogel Turbine Plant

Perhaps the most pleasing looking installation in the city, and the simplest for its size, is the 3100-kw. turbine plant installed by the above company in 1910. The two large turbines, of the horizontal reaction type, are painted light gray and black, and with the copper piping the contrast is attractive. The latest instruments and gages, nicely mounted, also add to the appearance; their records show that a kilowatt-hour at the switchboard is produced for 1.05c. This includes operating expenses, interest and depreciation, with a load factor on both boilers and turbines of about 45 per cent. For coal alone the cost per unit is 0.38c. Barometric condensers serve the turbines, and to prevent clogging by the dirty water from the Menominee River, special nozzles are so arranged that the openings are not restricted. A pressure of ¾ lb., or 1½ in. abs., is maintained in the condensers. The temperature of the water going to the hotwell is 90 deg., and to use it for industrial purposes in the tannery would save heating a fresh supply of water by live steam. To purify this very dirty water, however, one of the largest water softeners ever built, having a capacity of 150,000 gal. per hr., was placed in the plant. The water, being hot, assists in the process of softening, and as the main tank is 72 ft. high, it is distributed by gravity to the departments. In summer, the water only loses 1 or 2 deg. in the softener but loses 3 or 4 deg. in winter.

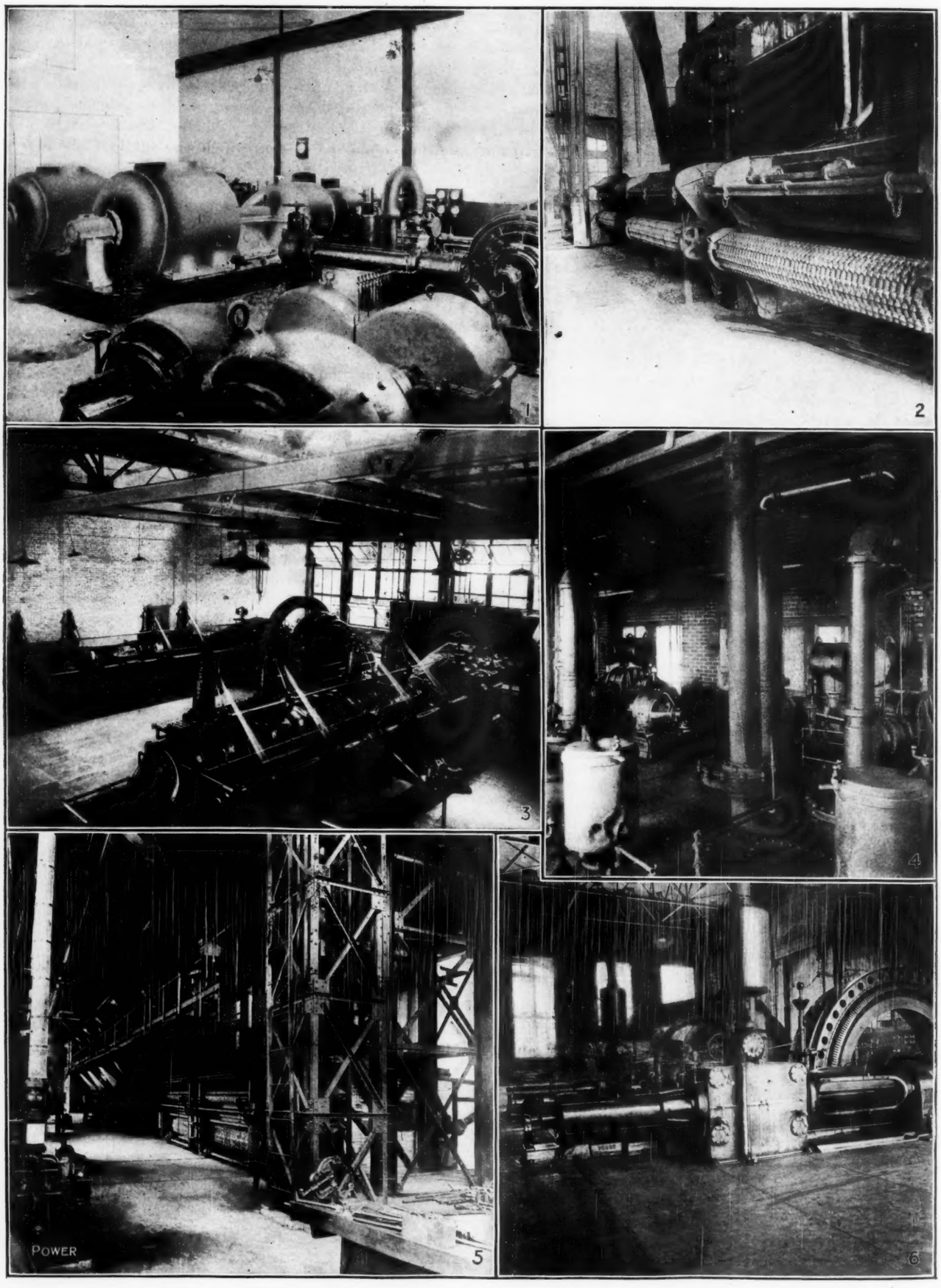
In the boiler room there are six water-tube boilers equipped with chain grates, a Darley pneumatic system of ash-handling and special facilities for getting the coal to the stoker hoppers. In the basement of the building containing the power plant there is a central hydraulic system for twelve elevators. The pump requires a 75-hp. motor, but 200 hp. or more would be required if individual electric elevators had been installed. In the basement of the new office building there is something of interest for the heating engineer—an air washer having a capacity to handle 40,000 cu.ft. of air per min. The air is blown into the rooms at 72 deg., and thermostatic control turns on direct radiation when the room temperatures drop below 70 deg.

A Producer Gas-Engine Plant

An 800-kw. producer gas-engine plant has been running without the slightest trouble for the past four years at the works of the A. O. Smith Co., makers of automobile parts, drop forgings and stampings. Soft coal is used in the producers and for the year 1913 the total cost per kilowatt-hour averaged 1.04c. This is made up of an operating cost of 0.634c. and a fixed charge of 0.47c. per unit. (See Power, of Mar. 10, 1914.) There are two 400-kw. tandem, double-acting engines, two 400-hp. pressure producers and two 350-hp. suction producers. The first two producers have rotary tar extractors and the others static tar extractors which latter were the second of their kind to be installed. (For further reference, this device was described in the Dec. 9, 1913, issue of Power.) The tar recovered is burned under heating boilers and per pound evaporates 9½ lb. of water. An interesting feature is the arrangement for utilizing the waste heat of the exhaust gases. The gas from the engines passes through a heater and then, in conjunction with waste gases from the annealing ovens, is delivered to hot-water heating boilers which are also equipped to burn either coal or tar. The engine jacket water which is passed through the heater is delivered to the boilers and any excess is sprayed and reused.

Central Stations

Of these there is quite a number. The Commerce Street station of the Milwaukee Electric Railway & Light Co. is described in a separate article in this issue.



VIEWS OF INTERESTING PLANTS IN MILWAUKEE

Fig. 1. Turbine room, Pfister & Vogel plant. Fig. 2. Pfister & Vogel Co.'s boiler room. Fig. 3. Gas engines, A. O. Smith Co.'s plant. Fig. 4. Top of gas producers, showing tar extractors, same plant. Fig. 5. Boiler room, Commonwealth Power Co. Fig. 6. Engines, Commonwealth Power Co.

The same company operates a plant on Oneida St. and another in the basement of the Public Service Building; both are run non-condensing and supply exhaust steam for heating. The Oneida St. plant, which supplies direct current only for railway and general service, has a capacity of 4750 kw. in five cross-compound vertical engine units and eight 500-hp. water-tube boilers equipped with underfeed stokers. Exhaust steam for heating is supplied to the business district east of the river and to a large area in the residence district, the connected load aggregating about 318,000 sq.ft. of radiation.

In the Public Service Building 60-cycle current at 4000 volts is generated. The main equipment consists of three 1500-kw. horizontal reaction turbines and ten 400-hp. water-tube boilers having underfeed stokers. The turbines are noncondensing and are run during the heating season to supply exhaust steam to the business district west of the river and a small part of the residence section. The lines consist of 1630 ft. of 16-in. pipe, 4460 ft. of 14-in. and 13,867 ft. of smaller pipe. The connected load is 170,000 sq.ft. of radiation.

The principal station of the Commonwealth Power Co. is also on Commerce St. It is a plant containing three cross-compound Corliss engine units served in common by a barometric condenser. A 3000-kw. reaction turbine and surface condenser are now being installed. There are six 500-hp., water-tube boilers with overhead bunkers and automatic scales to record the weight of the coal fed to the chain-grate stokers. Just above the station is the large coal yard of the Schlitz Brewing Co., with a storage capacity of 60,000 tons; it has two gantry cranes capable of unloading from a boat two tons per min. An 800-ft. belt carries the coal to the plant. As the clamshell buckets of the cranes are operated intermittently, the motors are supplied with 500-volt railway service from a 75-kw. motor-generator set which, to smooth out the irregularities in the demand, has a solid steel flywheel weighing 18,000 lb.

An Old Engine

At the John B. A. Kern & Sons flour mill, on the Milwaukee River between the two Commerce St. plants, is a Corliss engine which was installed in 1881. It has been on 24-hr. service, except Sundays, ever since, and is in excellent condition today. The engine is a tandem-compound, 28x56x48-in., developing at 65 r.p.m. a maximum output of 1000 hp. with steam at 125 lb. pressure. At the time of its erection it was the largest engine in the Northwest, and is said to be the first large machine built by Edwin Reynolds after his affiliation with the E. P. Allis Co. The original valve-gear is still intact. It is of the regular Reynolds type, but of heavier construction, as the solid wristplate will indicate. The usual flyball governor is belted to the main shaft and one eccentric operates the valve-gear of the two cylinders.

The engine has locomotive, or open, wrought-iron slides acting as braces from the housing of the low-pressure cylinder to the housing of the main shaft bearing. The bearing ends of the slides are fitted in slots and held by cross keys. An unusual feature is two piston rods between the low-pressure piston and the crosshead. The main connecting-rod has the old-style gib and key which has not been made for many years. The flywheel is 20 ft. in diameter and its 40-in. face is fitted with three belts, one over the other and leading to different floors. A jet condenser serves the engine. Two single-acting pumps, 16x20-in. driven by a double arm, remove the water and obviate the necessity of a foot valve. The shaft on which the double arm is mounted is rotated by a rockshaft, actuated through a connecting-rod by a reduced end on the crankpin.

The Garbage Incinerator

Killing two birds with one stone—that is, destroying its garbage and generating current for useful purposes—is what Milwaukee is doing with this interesting plant. Garbage is collected in the second story of the plant and fed downward into the furnaces. There are four independent units each having six fires and a capacity of 75 tons daily. The garbage is incinerated without the aid of fuel other than that found in the refuse matter. During the warmer weather better combustion is obtained by using cinders to separate the material. The gases from the destructor units are passed through 200-hp. water-tube boilers, of which there are four, although only three are used at any one time. With an evaporation of 1.25 lb. of water per pound of refuse there has been plenty of steam, but formerly most of it escaped to the atmosphere, only enough being used to generate current for the cranes, fans and lights. More recently, a generating station has been erected. It contains a 600-kw., single-stage, reaction turbine driving a three-phase, 4000-volt generator at 3600 r.p.m.; a Leblanc condenser serves the unit. Most of the current is transmitted to the Milwaukee River flushing station where the potential is reduced to 440 volts to serve a 350-hp. induction motor driving a centrifugal pump. The latter has a capacity of 21,000,000 gal. per hr. and during the day is supposed to replace the entire flow of the river. The station runs continuously six days a week and, besides the above load, lights McKinley Park and the bathing houses at McKinley Beach. At times, there is still steam to spare.

A Brewery Plant

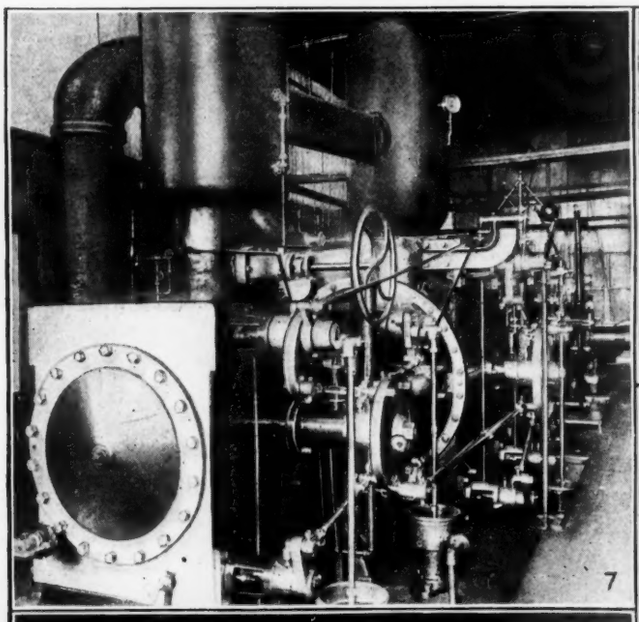
Those interested in refrigeration will naturally look to the large breweries, and of these Pabst is the nearest to the convention hall. In compressors there is a total capacity of 900 tons of refrigeration made up of two 300-ton, double-acting units and four 75-ton, single-acting machines, driven by Corliss engines. In the power plant there are two 400-kw., cross-compound vertical engines and one simple 300-kw. unit, all operating noncondensing and furnishing three-phase, 25-cycle current at 440 volts. From the simple unit steam is exhausted at 40-lb. pressure for cooking in the brewhouse.

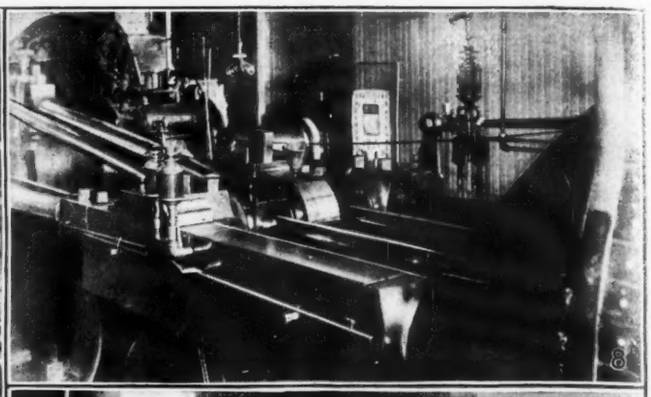
A new boiler room equipped with eight 400-hp. water-tube boilers, Murphy furnaces and economizers has replaced the one wrecked by the explosion five years ago.

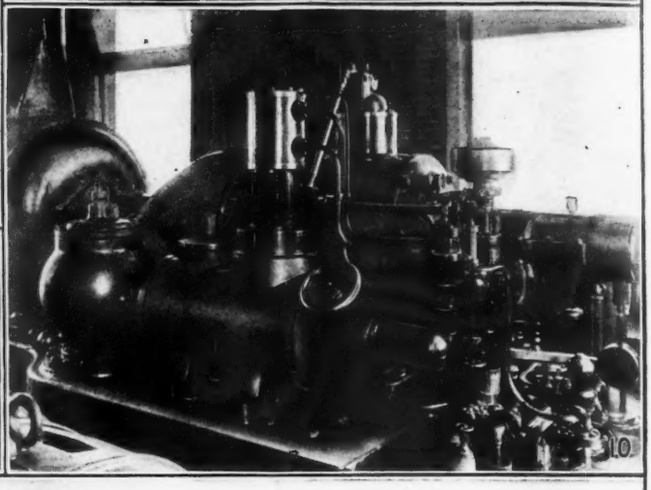
Coal is stored in individual overhead bunkers and weighed by hopper scales before reaching the furnace. It is delivered to the plant in a five-ton truck driven by worm gears instead of chains and having a hydraulic hoist. The truck has taken the place of four three-horse teams and one man operates it. Eighteen five-ton loads can be hauled in an 8-hr. day, the distance for the round trip being 3.4 miles.

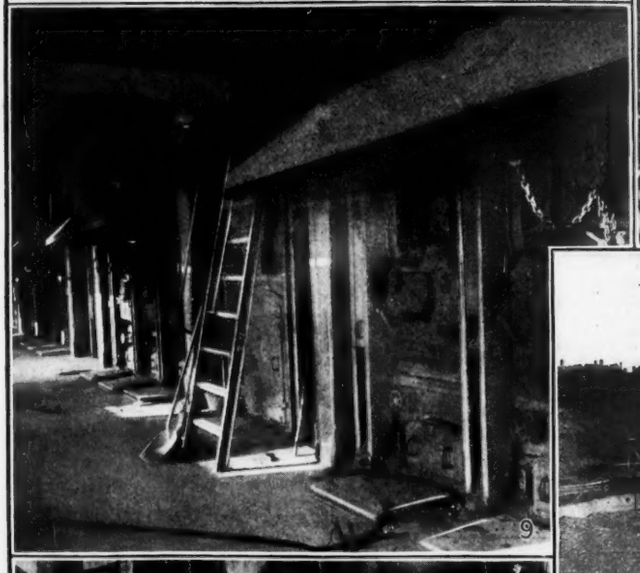
Coaling Plants

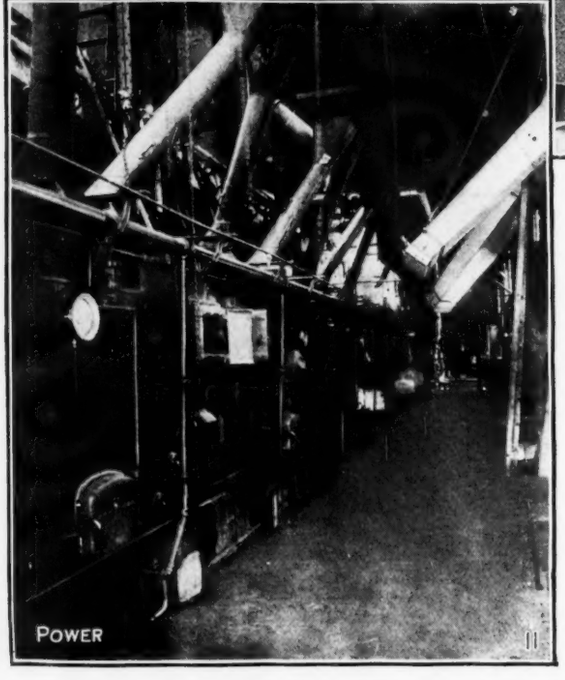
Milwaukee is called upon to care for more than 5,000,000 tons of coal in the comparatively short season of











MORE VIEWS FROM MILWAUKEE PLANTS

Fig. 7. Old Corliss engine, Kern Flour Mills. Fig. 8. Crosshead and guides of the old Corliss. Fig. 9. Boiler room of the incinerator plant. Fig. 10. Turbine using steam from incinerator plant. Fig. 11. Boiler room of Pabst brewery. Fig. 13. Coal yard of the Milwaukee Western Fuel Co.

navigation. There are twenty-eight receiving plants along the various channels leading to the lake and all are equipped with the most modern appliances for handling coal. Their combined storage capacity is something like 4,000,000 tons and the equipment represents an unloading capacity of 100,000 tons every 10-hr. The Sixteenth St. yard of the Milwaukee Western Fuel Co. has two portable 8-ton man-trolley bridges and two portable steel towers, the outfit being capable of unloading 2000 tons per hour. A revolving bridge at the works of the Milwaukee Coke & Gas Co. is said to be the largest gantry crane ever constructed. It has a clear span of 360 ft., a cantilever extension of 120 ft. and carries a 5-ton

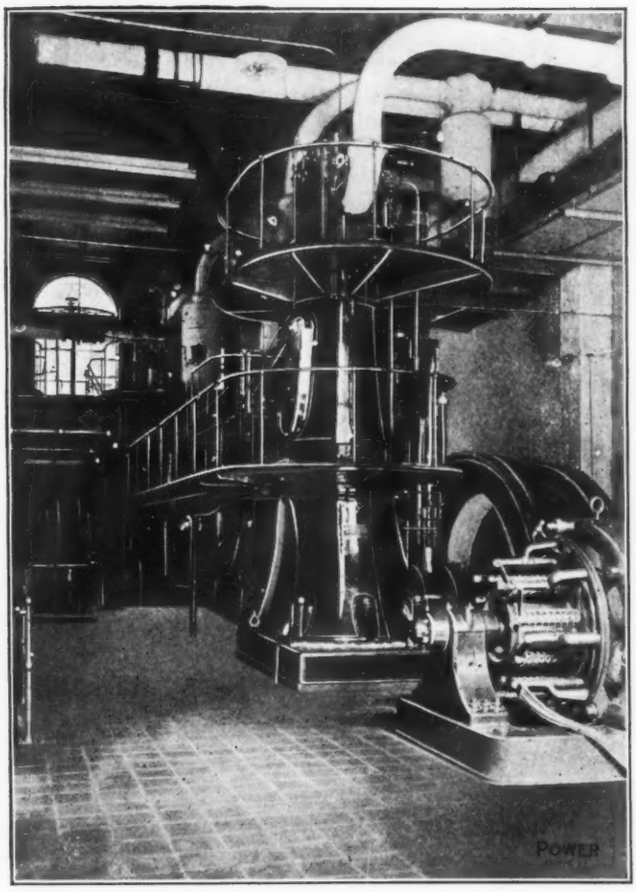


FIG. 12. VERTICAL ENGINES AT PABST BREWERY

bucket. Three fast hoists take coal from vessels at the rate of 300 tons per hour each, or a total of 900 tons. The plant was designed to handle 1,500,000 tons of coal over the dock in the course of a season. An interesting feature in the trade is the employment of two river barges equipped with elevating machinery to transfer the coal direct to bins or yards connected with power houses, thus avoiding a vast amount of teaming. The apparatus just referred to does not belong to the power plant, but it is handling a product familiar to all and in a way that is most interesting.

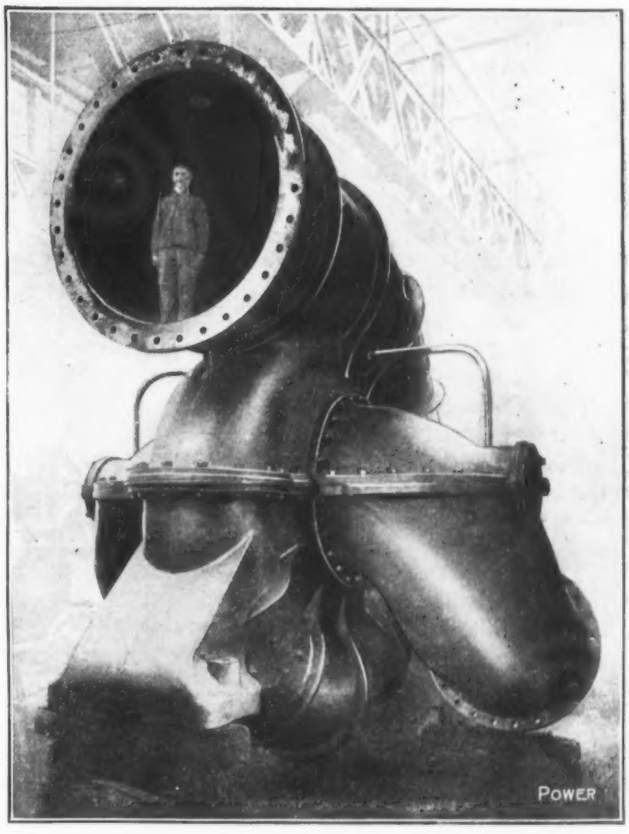
There are other plants in Milwaukee which are well worth a visit. At the public library the engineer keeps a most complete system of records, and the same is true at the plant of the Falk Co., which is producing current at an average cost of 1c. per kw.-hr. Then there are the manufacturing establishments turning out power plant products. A general knowledge of the finished article should create an interest to see how it is made and assembled.

A visit to any of the following plants would not be regretted: Allis-Chalmers Co., Avery Scale Co., Bayley Manufacturing Co., Chain Belt Co., Cutler-Hammer Manufacturing Co., Filer & Stowell Co., H. W. Johns-Manville Co., Nordberg Manufacturing Co., Pawling & Harnischfeger and the Vilter Manufacturing Co.

Another feature which may be of interest is the new experimental power plant just installed by the Central Continuation School, a public institution maintained by the city of Milwaukee to offer educational facilities for the workers. The Board of Industrial Education equipped the plant as a result of a petition of Wisconsin No. 1, N.A.S.E.

Largest Centrifugal Pumps Yet Built

The pump of which the photograph is reproduced herewith is one of five which are being built by the Southwark Foundry & Machine Co. for the Plaquemine & Jefferson Drainage District of Louisiana. Four of these pumps have 76-in. outlets and the fifth a 48-in. outlet. Their function is to pump water back over the levee into the Mississippi River for the purpose of draining a district near the Plaquemine Canal. The large pumps have a lift varying from 1 to 13 ft. and the smaller pump from 3 to 8 ft. The capacity is 168,000 gal. per min. at 1 ft. head, and 40,000 gal. per min. at 13 ft. head for the larger pumps; 47,500 at 3 ft. head, and 40,000 at 8 ft. head for the smaller pump. The usual head will be from 3 to 6 ft. The pumps are to be driven by compound condensing Nordberg Corliss engines, designed for



76-IN. CENTRIFUGAL PUMP FOR PLAQUEMINE DRAINAGE PROJECT

170-lb. gage initial pressure and 25½ in. of vacuum, and it is expected that a duty of about 95,000,000 ft.-lb. per 1000 lb. of steam will be obtained with the larger, and 85,000,000 with the smaller pump.

The Word "Zero" is from the Spanish, and means empty, hence nothing. It was first used for the thermometer in 1795 by the Prussian merchant and physicist Fahrenheit.

Massachusetts Boiler Law and Rules--II

By C. O. Andrews

SYNOPSIS—Continuing the discussion of the rules drawn by the Massachusetts Board of Boiler Rules, this installment deals with those included in Part III.

Part III—Section 1

Since part three applies only to boilers to be installed after the passage of the law, the greatest latitude was allowed in making the rules, for they could not affect the property rights of anyone.

Section 1 deals with the chemical and physical qualities of the materials to be used in boilers and how such qualities are to be ascertained. Some steel manufacturers have objected to the chemical qualities called for by the rules, but the requirements are apparently none too stringent and can be easily met by the manufacturer of good boiler plate.

The physical qualities could be changed to advantage from every viewpoint. The present scheme of fixing pressures induces the boiler manufacturer to secure plate of as high tensile strength as possible and keep within the limit prescribed by the rules (62,000 lb. per sq.in.). This means that the plate will come between 57,000 and 62,000 lb. tensile strength per square inch. While the rules no doubt intended having the average tensile strength about 57,000 lb., the plate actually being used probably ranges around 60,000 lb. Steel manufacturers and nearly all authorities acknowledge that material of 50,000 or 52,000 lb. per sq.in., would be better and that boilers constructed of it would stand the same presure for a given thickness more safely.

Preferably, a range of tensile strength from 50,000 to 60,000 lb. should be required and the pressure allowed on the lowest tensile strength, or on the average tensile strength of the range, fixed without reference to the actual tested strength of the material.

No comments are offered in connection with the rest of this section; the various paragraphs follow the standards prescribed by the American Society for Testing Materials and have been in common use for a long time.

Section 2

Paragraphs 4 and 5, which deal with the tensile strength of cast steel and cast iron to be used for superheaters and also for boiler attachments, specifying the values required but not how the test pieces are to be obtained; instructions on this point are necessary to be certain of results. Limiting the pressure on boilers, the headers, drums or other parts of which are made of cast iron, to 150 lb. as specified in *paragraphs 6 and 7,* is wise.

Paragraphs 10 and 11 specify that water-leg and door-frame rings for locomotive and vertical fire-tube boilers must be wrought or cast steel. As there is no danger from using cast iron for such parts these paragraphs seem superfluous.

Section 3

Paragraph 2 of this section deals with the stamping of boilers at the place of manufacture; some provision should be made for correcting improperly stamped boilers when an error has been made by the stamper. Simple mistakes in stamping have brought inspectors and the representatives of boiler manufacturers long distances, merely to change the location of a letter or to change a number on the stamp.

Paragraph 5 concerns the location of stamps on boilers of various types. The rule is well arranged, but could be improved in two respects. Under item (c) the location of stamps for locomotive and Star water-tube boilers is designated as on the furnace end and above the handhole.

These boilers may have more than one handhole on the firebox end, and then the boilermaker does not know over which one to place the stamp. It would be better if the location had been given as above the fire-door and about on a line with the crown sheet and above the handhole, if one should be located at this point.

Under (d) the location for the stamping is designated for vertical tubular and submerged tubular boilers, as on the sheet above the furnace door. The same suggestion as before would apply in this case, and the instructions would apply equally well to any of the types mentioned. The reason for stamping above a handhole is that leakage is liable to corrode the plate below it and obliterate the stamp.

Section 4

Section 4 is extremely long and deals with many parts of boiler construction. *Paragraphs 1, 2 and 3* deal with the calculation of the shells of drums which are pierced by tube holes, and the same criticism seems to apply as to the methods to be used in calculating the efficiency of riveted joints. The mere statement that the strength of the ligament between the tube holes must be taken into account in calculating the strength of such drums would be sufficient, as far as the rule is concerned. The detailed description of how to determine the efficiency of the tube ligaments, should be given in an appendix. The instructions in the case of staggered holes, while not mathematically correct, are near enough for all practical purposes and avoid involved calculation.

Paragraph 4 deals with staying heads of small boilers for pressures of 100 lb. or less, with angle-iron stiffeners. Most of this matter preferably should be in an appendix. The strength of only the outstanding leg of the angle is considered in the calculations. This is justified, since it is on the side of safety and simplifies the calculation. One of the most important features in connection with angle-iron stiffeners has been omitted, i.e., how the ends of the angles should come, in relation to the turn of the flange on the head.

Lengths are given for angles to be used for bracing the heads of boilers 30 and 36 in. in diameter, but these dimensions would not answer for a 26-in. or 34-in. head. It would be better to state the maximum fiber stress to be allowed on the supporting members and that they must come well up on the turn of the flange of the head to be supported; or better still, to specify the size and number of angles to be used on each side of the boiler

and the approximate spacing of the rivets to attach the angles to the heads. Since the maximum pressure to be used on boilers braced in this manner is limited to 100 lb. and the range of sizes to be covered is small, no difficulty should be experienced in treating the subject in this manner and it would remove the necessity of placing in the book beam formulas which are not and need not be understood by the average inspector.

Paragraphs 5 and 6 deal with longitudinal joints and specify that on boiler shells exceeding 36 in. in diameter, they must be of the double-butt strapped type, and on boilers 36 in. or less in diameter, for pressures not exceeding 100 lb. the lap joint may be used. These provisions are all good, but a higher factor of safety should be required on boilers having lap joints. The fact that the diameter of the boilers is small, does not prevent the formation of lap-joint cracks, in fact, a small cylinder is more likely to be out of true at the seams than a large one.

Probably there are not more explosions due to lap cracks, on small-diameter boilers, on account of the short courses producing a stiffer structure. An increase in the safety factor would likewise insure a structure of greater stiffness. Limiting the pressure on lap-seam boilers to 100 lb. is not enough safeguard for some of the most disastrous explosions have occurred at pressures below this. It might be thought that elimination of the lap seam would remove all questions, but such a course could hardly be justified. Placing double-butt strapped joints on cylinders of small diameter is sometimes difficult if not impractical and the facilities for fitting in some shops are such that the lap seam is probably more reliable than a seam of the butted and double-strapped type.

Paragraph 9 states that horizontal return-tubular, vertical tubular and locomotive boilers, cannot have a continuous longitudinal seam over 12 ft. long. Long longitudinal seams on these types would not be more dangerous than on other boilers. This limitation was probably an attempt to avoid interference with the standard construction of some types of water-tube boilers, but if regarded as a menace to safety, long seams should have been prohibited on all types, since the rules in this part refer only to boilers to be installed after the passage of the law.

Paragraph 10 requires that the thickness of the plates in the shells of drums be of the same gage. This does not seem a necessary rule for safety and interferes with at least one standard make of water-tube boiler.

Paragraphs 11 and 12 give the minimum thicknesses of plates to be used in boilers. This is a good rule for it is necessary to prescribe such limits, i.e., the shells must be at least ¼ in. thick and for diameters over 36 in. and including 54 in., the thickness must be at least $\frac{5}{16}$ in., above 54 in. and including 72 in., the shell must be ⅜ in., and for all diameters over 72 in., the shell must be at least ½ in. This range of minimum thickness is conservative and regardless of the pressure to be carried, no boiler should be built of material of less thickness than specified.

Paragraph 14 states that butt straps are to be rolled or formed to the proper curvature, on forms made for the purpose. While this is important, it is much more so that the ends of the shell sheets, where the longitudinal seams are to come, be properly formed. Nothing in the rules states how the ends of the sheets at the joint are to be formed. Usually the rivet holes are punched for the longitudinal seam and then the plate is placed between the rolls (turned in the opposite direction from the one in which it is intended to be rolled), the plate is then sledged down over the bottom roll along the line of the longitudinal seam. This seriously injures the metal and should be prohibited. It should be required that the ends of the plate be formed under a press to the proper curvature. While a hydraulic press is preferable, the work could be done properly under a screw press, hence the equipment cost would not be unreasonable for any boiler manufacturer.

Paragraph 15 on the minimum thickness of tube sheets, is good, but this thickness should depend on the tube diameter as well as the boiler diameter. A rule should prescribe the minimum space to be allowed between the tube holes for given thicknesses of tube sheets and diameters of tubes.

Paragraph 16 determines the thickness for bumped heads and copies the old Government rule on the same subject. The formula given is based on the assumption that a portion of a sphere cut off and attached to the end of a cylinder will behave as if it were still part of the original sphere. Practice has proved this is a fallacy and a new rule should be made to establish the thickness for bumped heads.

Paragraph 21, giving a table of maximum pitches to be allowed for staybolts in the formula, is too conservative for the spacing could be increased safely. The latter part of this paragraph states that, when hollow stays are used having holes ½ in. or over in diameter, the pitch of the bolts may be increased by the mean diameter of the bolts. This rule was without doubt made to avoid conflict with the construction of some of the existing types of water-tube boilers. While, with a given thickness of sheet, larger staybolts could be safely spaced farther apart, as far as the strength of the sheet is concerned, the size of the hole in the bolt could have no influence on the proper spacing. Some water-tube boilers have hand holes cut in one of the stayed members and tube holes in the other, and it has been demonstrated that the rules are over-conservative as applied to such construction. A logical rule to cover the situation, would be better than an arbitrary one without reason.

Paragraph 22 gives an arbitrary rule for the staying of internal furnaces of not over 38 in. diameter, intended for the furnaces of small vertical tubular boilers and is without doubt safe, but it is inconsistent, in that the holding power of the staybolts is to be depended on considerably and the minimum thickness of furnace plates is not made to correspond to those given in *paragraph 19*, where $\frac{5}{16}$ in. is the minimum.

The rules are not complete with respect to furnaces, for they give no formula to determine the strength of Morrison or other types of self-supporting furnaces.

Paragraph 28 explicitly explains how to figure the area to be stayed on the heads of horizontal tubular boilers, and the table in *paragraph 29* gives the areas to be stayed on boilers of various diameters with segments of varying height. This table is well arranged and saves boiler inspectors and manufacturers much work besides tending to eliminate mistakes.

The formula in *paragraph 30,* for determining the area to be stayed, when not given in the table, is simple and sufficiently accurate for practical use. A defect in the

law is the failure to fix pressures for unbraced boiler heads. Many boilers in the state do not comply with the law as it now reads and the inspection department has been compelled to overlook violations. Since no provisions have been made, segments over 5 in. high would have to be braced to comply strictly with the rules, this 5 in. being made up of the 2-in. allowance from the tubes and the 3-in. space from the shell of the boiler.

Many horizontal return-tubular boilers, of considerable size, have greater distances from the tubes to the shell at the side of the boiler than would be allowed by a limit of 5 in. and braces on such surfaces would decrease the safety of the boiler. Boilers of other types also necessarily violate this part of the rules. Provision should be made to permit a reasonable pressure on the segment of a head, or on a round head, without requiring braces; a formula similar to Nicholls' Rule would answer.

Paragraph 31 specifies that where a man-hole opening is flanged in, to a depth of twice the thickness of the head, an area 2 in. wide all around the man-hole opening may be deducted from the total area to be braced. This rule does not seem to be logical for cutting a manhole in the head of a large boiler cannot change the amount of bracing required to safely support the head.

Paragraph 32 is not clear as to how the bracing is to be attached to the rear head of the boiler. The rule states that the rear ends of the braces are to be attached to the rear head of the boiler, but it is not feasible to attach these ends except through crowfeet or similar devices, the questions arise as to how far apart the rivets shall be spaced and also whether the spacing of the braces or of the rivets which attach them to the head must conform to the spacing required for staybolts on flat surfaces. It is not practical to space braces the same as stays, although the surfaces supported must be considered stayed surfaces. Some rule should be adopted which would overcome this difficulty.

In *paragraph 35,* devoted to the stress per square inch allowable on different kinds of stays and staybolts, unreasonable variations are allowed. The values closely follow such allowances as are given in the Steamboat Inspection Rules. There is no reason why a large diameter brace should be allowed a higher stress than one of small diameter. The smaller brace, exposing relatively greater surface, will deteriorate more rapidly, but this does not warrant the difference allowed, especially as the material of the smaller brace is somewhat stronger than that of the larger one. The values for allowable stresses on braces are probably too conservative. Those given for the larger braces would no doubt be perfectly safe for braces of all sizes.

Pittsburgh Smoke Ordinance—A new ordinance has been passed in Pittsburgh, the enforcement of which hinges upon the use of the Ringlemann chart. The new measure provides penalties—fines of from $10 to $100, or imprisonment from 5 to 30 days, for each violation—for the production of smoke equal to or greater in density than scale 3 on the chart. The restrictions read as follows: "The production or emission within the city of smoke, the density or shade of which is equal to or greater than No. 3 of the Ringlemann chart, from any stack, except that of a locomotive or steamboat, for a period or for periods aggregating two minutes or more in any period of 15 min., and the emission of such smoke from any locomotive or steamboat for a period or periods aggregating one minute or more in any period of eight minutes, except for a period not to exceed 20 consecutive minutes, not to exceed once a day, while a new fire is being built therein, is hereby prohibited."

Universal Handhole Scraper

A scraper to be used on the countersunk gasket seat of the handholes in the forged-steel water legs of high-pressure water-tube boilers is shown in Figs. 1 and 2.

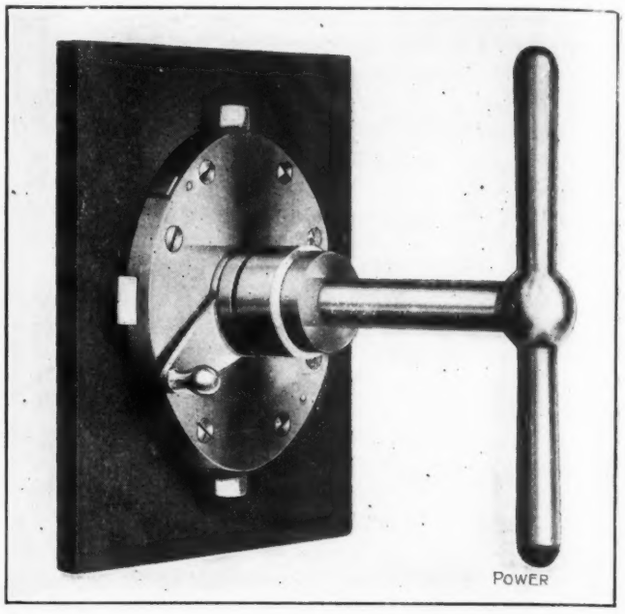


FIG. 1. FRONT OF THE HANDHOLE SCRAPER

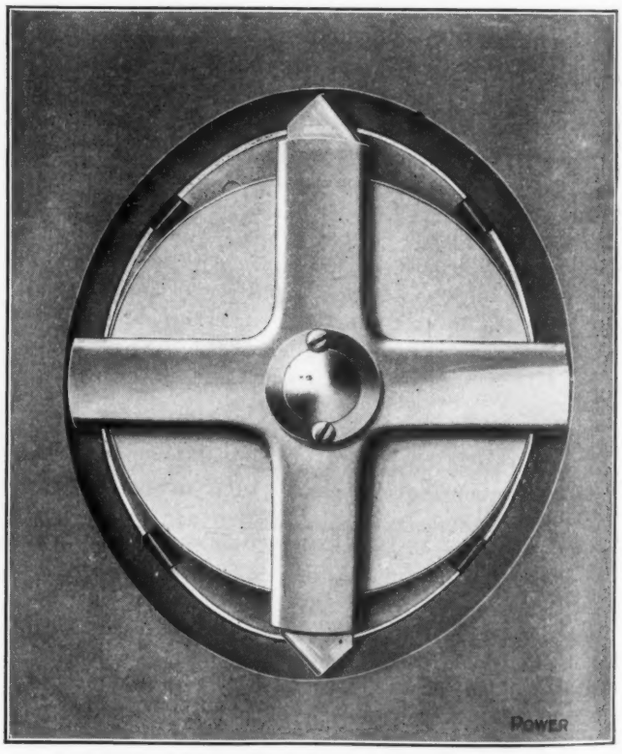


FIG. 2. BACK OF THE SCRAPER

The tool will clean the gasket seat perfectly in from six to ten seconds. It is inserted in the handhole, just as a plate would be, and the little lever on the left is moved downward until the clutching blades take hold and fasten the tool firmly in the hole. These blades have beveled ends grooved to prevent them from slipping and allow the body of the tool to teeter while in operation.

The beveled ends cause the scraping blades to be pressed evenly against the gasket seat. As the tool is turned in the hole, it becomes loose or relaxed. This means that the gasket seat has been partially cleaned, and it is necessary to move the chucking lever farther downward. If necessary, this movement is repeated a third time, as the tool is revolved in the hole, and when the lever has been moved to the stopping point downward and the tool turns easily, it will be known that the gasket seat is clean. Under ordinary conditions, five or six turns of the scraper to the right will be sufficient.

There is a coiled impression spring in the collar of the tool, shown just above the body, which regulates the pressure of the scraping blades on the gasket seat. These blades are so constructed that they have a "lead" or shearing movement over the gasket seat, which tends to prevent chattering.

The four flat springs shown on the outer edge are for centering the tool. The spider carrying the scraping blades is so fastened to the handle that movement similar to a universal joint is obtained. This assures an even seating of the blades upon the gasket seat. There is a thin, spring-acting disk between the spider and the body of the tool which keeps the dirt and scrapings out of the working parts, as well as permitting an automatic takeup for wear on the blades. The tool is made by the Universal Handhole Scraper Co., 326 West Madison St., Chicago.

Hand-Fired Furnace for Water-Tube Boilers--II*

By Osborn Monnett†

SYNOPSIS—Typical designs of semi-extension furnaces for horizontal water-tube boilers burning wood refuse, for horizontal boilers vertically baffled and for vertical boilers.

Semi-Extension Furnaces

With boilers having 16-ft. tubes where it is desired to burn a large amount of wood refuse, it is difficult to install a hand-fired furnace which will give a satisfactory ratio of grate surface to heating surface, for the reason that when the furnace is installed it will be found that the opening into the bank of tubes is restricted. It is desirable here to install a semi-extension, dutch-oven furnace which will dispose of an enormous quantity of wood refuse and allow a large grate surface to be installed where large capacities must be obtained from the equipment. This type of furnace is especially desirable where the wood refuse is wet as it gives an igniting effect not obtained in the flush-front settings shown in the last article. It is not advisable, however, to use this setting where any considerable quantity of coal is to be burned, as almost invariably the setting will smoke when burning coal alone.

Fig. 7 shows a semi-extension furnace with a deflection arch, adapted to an Atlas boiler. In this particular setting it was found that with box tile over the bridge-wall the temperature was too high for good results, so that half of the box tile was removed, leaving the tube surface in the front half of this zone bare to the fire. This had a steadying effect on the water level in the boiler and increased heat absorption with a corresponding decrease in the temperature of the brickwork. A deflection arch in two spans is installed 36 in. behind the bridge-wall and two 13-in. piers are placed on the bridge-wall opposite the spans in the arches. The gas passes through the bank of tubes in three sweeps, as will be apparent in the drawing, passing thence along the superheating tubes to the uptake. This setting is for a 250-hp. boiler and

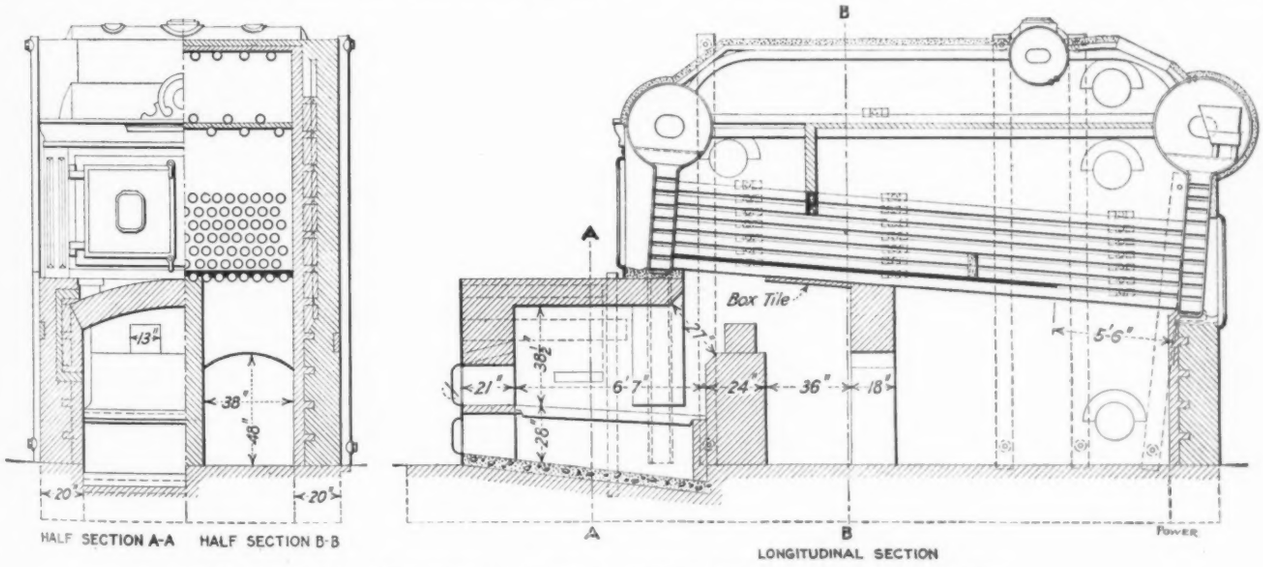


Fig. 7. Semi-Extension Furnace under Atlas Water-Tube Boiler

*Copyrighted, 1914, by Osborn Monnett.
†Smoke inspector, City of Chicago.

the extension from the front header measures 6 ft. over all.

Fig. 8 shows another semi-extension dutch-oven furnace for burning wood refuse exclusively. All essential dimensions of the setting are shown on the drawing. In

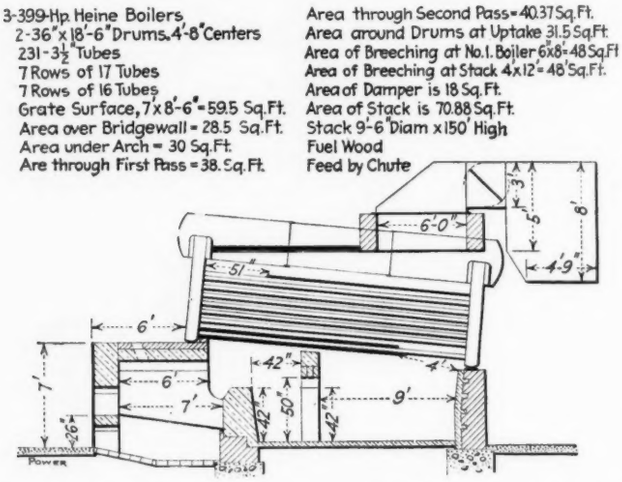

3-399-Hp. Heine Boilers
2-36" x 18'-6" Drums, 4'-8" Centers
231-3½" Tubes
7 Rows of 17 Tubes
7 Rows of 16 Tubes
Grate Surface, 7 x 8'-6" = 59.5 Sq. Ft.
Area over Bridgewall = 28.5 Sq. Ft.
Area under Arch = 30 Sq. Ft.
Are through First Pass = 38.5 Sq. Ft.
Area through Second Pass = 40.37 Sq. Ft.
Area around Drums at Uptake 31.5 Sq. Ft.
Area of Breeching at No. 1. Boiler 6x8 = 48 Sq. Ft
Area of Breeching at Stack 4x12 = 48 Sq. Ft.
Area of Damper is 18 Sq. Ft.
Area of Stack is 70.88 Sq. Ft.
Stack 9'-6" Diam x 150' High
Fuel Wood
Feed by Chute
6'-0"
51"
4'-9"
6'
7'
42"
50"
9'
26"
POWER

FIG. 8. HEINE BOILER WITH SEMI-EXTENSION WOOD-BURNING FURNACE

this case the box tile is carried completely over the bridge-wall and the gas pass is of the standard Heine type. It will be noticed that the height from the floor line to the front header is 7 ft. and that the chute feeds through the top of the arch. Also, the grates are pitched 12 in. at the bridge-wall, giving an unusually high bridge-wall and causing the gases to pass upward against the box tile before being directed against the deflection arch. This tends to prevent smoke formation as the gases and the air are thoroughly mixed.

Fig. 9 shows another semi-extension setting in which the bridge-wall is set a considerable distance under the tom of the front header to the floor line. To get the proper areas it was necessary to excavate in the combustion chamber.

One of the most important considerations in operating these furnaces is air admission. Shavings must be supplied with large volumes of air from the top if they are to be consumed without smoke, so that special attention

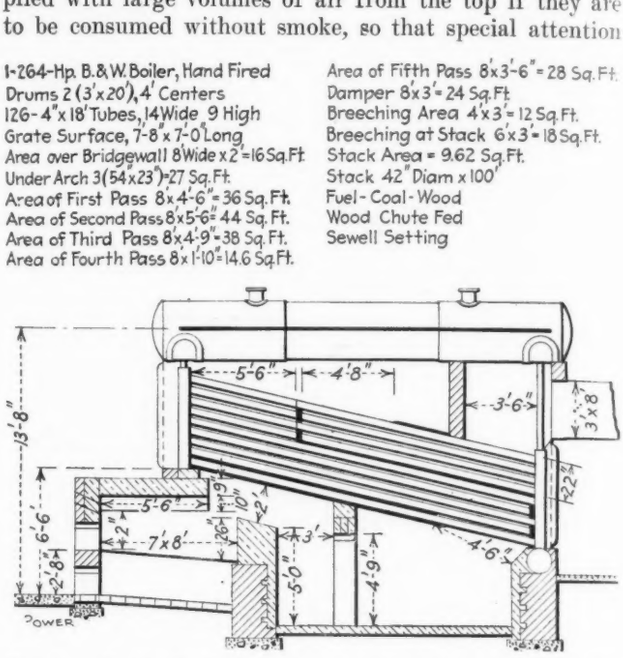

1-264-Hp. B. & W. Boiler, Hand Fired
Drums 2 (3' x 20'), 4' Centers
126-4" x 18' Tubes, 14 Wide 9 High
Grate Surface, 7'-8" x 7'-0" Long
Area over Bridgewall 8 Wide x 2" = 16 Sq. Ft.
Under Arch 3 (54" x 23") = 27 Sq. Ft.
Area of First Pass 8' x 4'-6" = 36 Sq. Ft.
Area of Second Pass 8' x 5'-6" = 44 Sq. Ft.
Area of Third Pass 8' x 4'-9" = 38 Sq. Ft.
Area of Fourth Pass 8' x 1'-10" = 14.6 Sq. Ft.
Area of Fifth Pass 8' x 3'-6" = 28 Sq. Ft.
Damper 8' x 3' = 24 Sq. Ft.
Breeching Area 4' x 3' = 12 Sq. Ft.
Breeching at Stack 6' x 3' = 18 Sq. Ft.
Stack Area = 9.62 Sq. Ft.
Stack 42" Diam x 100'
Fuel - Coal - Wood
Wood Chute Fed
Sewell Setting
5'-6"
4'-8"
3'-6"
13'-8"
7'x8'
4'-6"
5'-0"
4'-9"
POWER

FIG. 9. B. & W. BOILER WITH SEWALL BAFFLE AND REFUSE-BURNING FURNACE

must be given to the admission of air through the panels after firing. If the fuel is fed with scoops it is frequently necessary to run with the doors practically wide open, where the fire is charged frequently, as it is impossible to get sufficient air through the grates to consume the fuel without smoke.

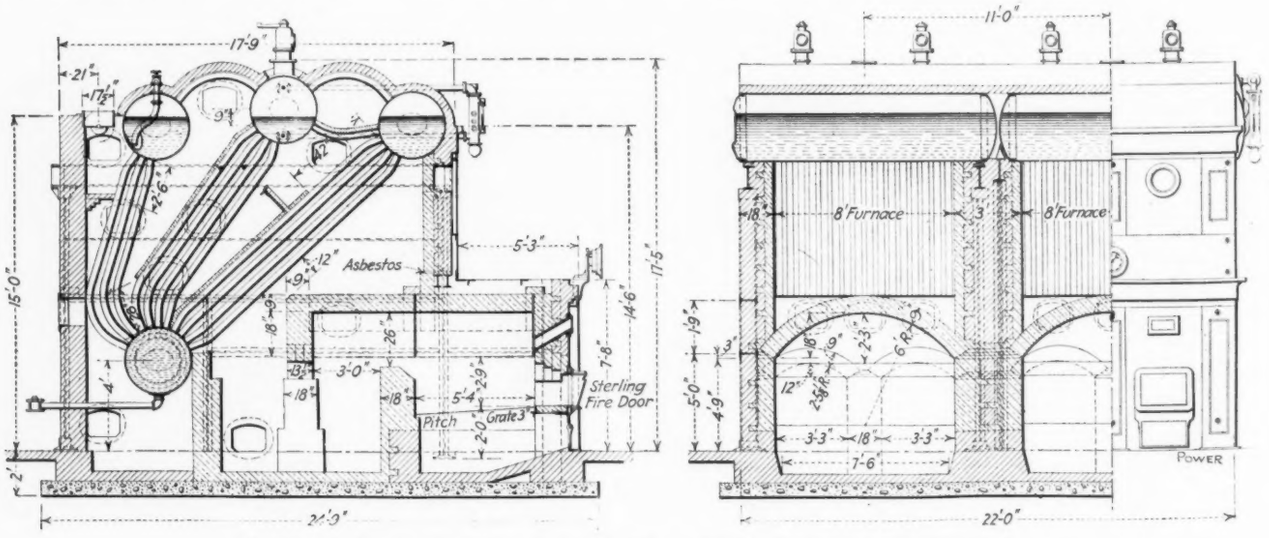


FIG. 10. STIRLING BOILER WITH HAND-FIRED DUTCH-OVEN FURNACE

boiler and the extension is brought down to a minimum. This construction decreases the floor space occupied and lowers the first cost as well as the maintenance. The boiler is of the Babcock & Wilcox type and is provided with Sewell baffling. It is only 6 ft. 6 in. from the bot-

Where the fuel is chute fed the excess air being discharged through the blower system aids materially in running smokelessly. However, there will be times when the furnace will be practically full of fuel, and at such times it will be necessary to open the doors wide. Where

the quantity of fuel is excessive it has in one or two instances been found advantageous to make a couple of square openings in the top arch near the front of the furnace through which excess air is supplied at all times. This expedient has been applied with success to some chronic smokers burning wood refuse. These unusual measures may seem to be inadvisable from the standpoint of economy, but where smoke is a prime consideration, it may be sometimes necessary to adopt them, as wood refuse and shavings form one of the most difficult fuels to burn smokelessly.

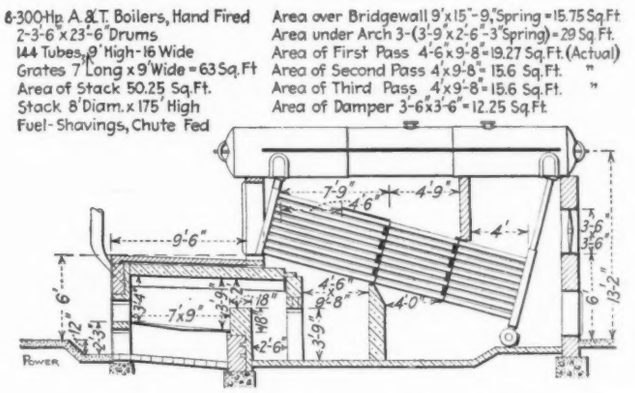

6-300-Hp. A.&T. Boilers, Hand Fired
2-3'-6" x 23'-6" Drums
144 Tubes, 3" High-16 Wide
Grates 7' Long x 9' Wide = 63 Sq. Ft
Area of Stack 50.25 Sq. Ft.
Stack 8' Diam. x 175' High
Fuel-Shavings, Chute Fed
Area over Bridgewall 9' x 15"-9" Spring = 15.75 Sq. Ft
Area under Arch 3-(3'-9" x 2'-6"-3" Spring) = 29 Sq. Ft.
Area of First Pass 4'-6" x 9'-8" = 19.27 Sq. Ft. (Actual)
Area of Second Pass 4' x 9'-8" = 15.6 Sq. Ft. "
Area of Third Pass 4' x 9'-8" = 15.6 Sq. Ft. "
Area of Damper 3'-6" x 3'-6" = 12.25 Sq. Ft.
7'-9"
4'-6"
4'-9"
9'-6"
4'
3'-6"
3'-6"
6'
13'-2"
4'-6"
9'-8"
4'-0"
7'x9"
18"
2'-6"
3'-9"
POWER

FIG. 11. AULTMAN & TAYLOR BOILER VERTICALLY PASSED AND EQUIPPED WITH WOOD-REFUSE-BURNING FURNACE

passing this point. This will also increase the life of the brickwork. The ordinary ratios of gas passes to grate surface previously given will hold up to 150 per cent. of rating. Above this, increase them proportionately.

VERTICAL BOILERS

Fig. 10 shows a typical furnace for a Stirling or any other boiler which does not lend itself to the horizontal gas pass, such as the Erie City vertical, the Milne, Hogan, Rust, Wickes vertical, etc. The unit is rated at 185 hp. The extension is 5 ft. 3 in. and the height of the dutch oven 7 ft. 8 in. The ratio of grate to heating surface is 1 to 45. The deflection arch is made in two spans.

It is easy to make a mistake in a setting of this type. If any restriction occurs in the baffling of the tubes, under the deflection arch, or in the zone back of the bridge-wall, or if the stack is not of sufficient height to give ample draft, the heat will be "bottled" in the furnace and radiated out into the boiler room; the brickwork will not stand the temperature and the capacity will not be obtained.

The best coal to burn in this furnace is a clean 3x6-in. egg, as it takes longer to distill the gas out of coal of this size. A smaller coal that gives up its volatile too rapidly would not be satisfactory, owing to the intense heat forcing the gas out in puffs that could not be controlled.

HORIZONTAL BOILERS VERTICALLY PASSED

When speaking of the application of hand-fired furnaces to water-tube boilers, it is natural to inquire what will be the possibilities when using the standard vertical gas passes on boilers of the horizontal type. This setting, while common throughout the country, is one which does

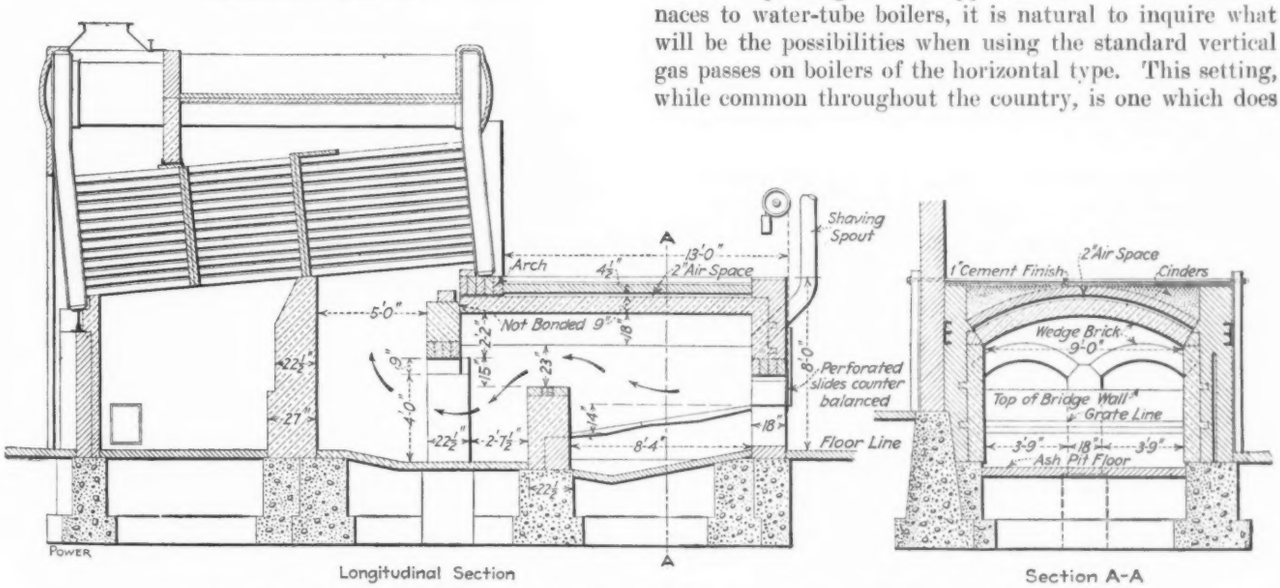


FIG. 12. EDGE MOOR VERTICALLY PASSED BOILER WITH WOOD-REFUSE-BURNING FURNACE

On the other hand, it must be admitted that this fuel is only a waste product in any event, and if the efficiency falls off a trifle, due to excess air, the actual financial loss is slight. As a matter of fact, the capacities can be high provided the draft is sufficient. A 500-hp. boiler using a furnace similar to the foregoing has been run continuously at 800 hp. without smoke.

When designing a wood-refuse-burning furnace it is of importance to know approximately at what capacity the unit will be run. If the capacity goes up over 150 per cent. of rating, it will be necessary to supply more area between the back of the bridge-wall and the deflection arch to take care of the large volume of gases not lend itself to smokeless operation. The flame travel is short and the dampening effect of the tubes in the first pass is such that complete combustion is not obtained. Moreover, it is practically impossible to modify the hand-fired type of furnace using the vertical pass and get a satisfactory installation from all standpoints. The ordinary dutch-oven furnace as applied to the vertical-pass boiler does not provide sufficient flame travel and gas mixture to be considered successful under a strict smoke ordinance. If the dutch oven is extended sufficiently to get flame travel and deflection, the installation becomes unwieldly and expensive from the standpoint of floor space occupied, first cost and maintenance. For the or-

dinary power load when burning coal, it has been found practically impossible to use this kind of baffling with hand-fired furnaces.

There have been a few chute-fed wood-refuse furnaces installed in connection with the vertical baffle which are giving good results, but ordinarily such an installation could only be made when building new and where floor space is unlimited. Fig. 11 shows this kind of a furnace which is run at high capacity and is satisfactory from the smoke standpoint; the maintenance item, however, is high. The setting is applied to a 300-hp. Aultman & Taylor boiler and the total extension is 9 ft. 6 in. from the front flue caps. The floor was excavated considerably to get the furnace in under the front header and the deflection arch was installed as in the original design of hand-fired furnaces. The deflection arch is in two spans and there is ample space between the deflection arch and the first baffle wall for the gases to enter the heating surface. The furnace is chute fed and burns shavings with success up to a rate of 120 lb. per sq.ft. of grate surface per hour. The furnace could not be recommended for the use of coal exclusively.

Another setting with a 13-ft. extension applied to an Edge Moor boiler is shown in Fig. 12. This was installed new, and ample floor space was provided for the furnaces as well as head room under the front header. The firing doors are suspended by counterweights and offer ample provision for admitting excess air in times of emergency. Such furnaces when properly handled will run smokelessly, but the slightest carelessness will cause them to smoke badly. At best, they need careful watching at all times.

Continuous Feed-Water Regulator

The use of the steam-flow meter has brought to notice the surprising variation in the rate of steaming of individual boilers. A boiler supposed to be running at a given capacity would be shown by the diagram from the meter to be running at times at twice its average capacity, while at other times its output would be practically stopped.

The method of introducing the feed water has much to do with the rate of steaming, as may be appreciated when the effect of pouring a dipperful of cool water into a boiling kettle is considered. If the water is dribbled in only fast enough to replace that evaporated, the steaming will go on at a uniform rate, while if the replenishing is done by the dipperful the boiling will be intermittent. Aside from its effect upon the steaming, abrupt changes in the rate of feeding are not conducive to good results with water meters, especially of the Venturi or pitot-tube type.

In view of these facts, particular interest attaches to a feed-water regulator which will maintain an approximately constant water level by regulating the rate of flow rather than by admitting the feed intermittently. Such a regulator, invented by Frederick L. Ray, and manufactured by the Ray Manufacturing Co., of 1035 Edwards Ave., Louisville, Ky., is shown in Fig. 1.

A piston valve, operated by the float in an obvious manner, controls the passage of the feed water from the inlet to the outlet port, adjusting the opening at *A* to that required to supply the water as fast as it is evaporated. By turning the handwheel *B* to the right, the valve may be pushed open positively in case of necessity, or its freedom tested.

At full load, when the valve is wide open, the water level will be about 2½ in. lower than when the valve is just opening, which is an advantage, giving a large body

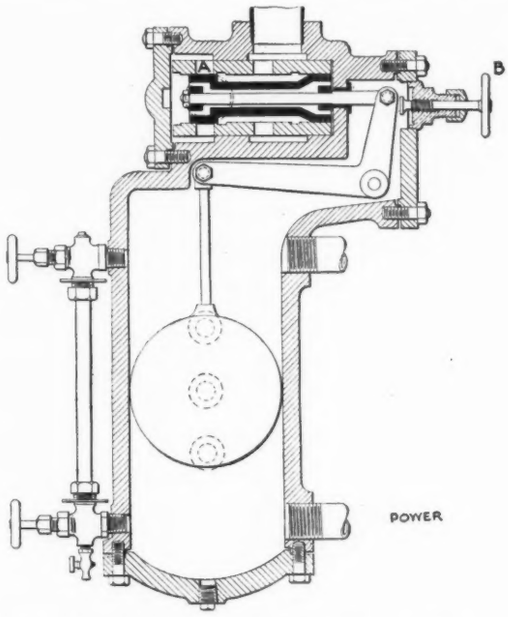


Fig. 1. Ray Continuous Feed-Water Regulator

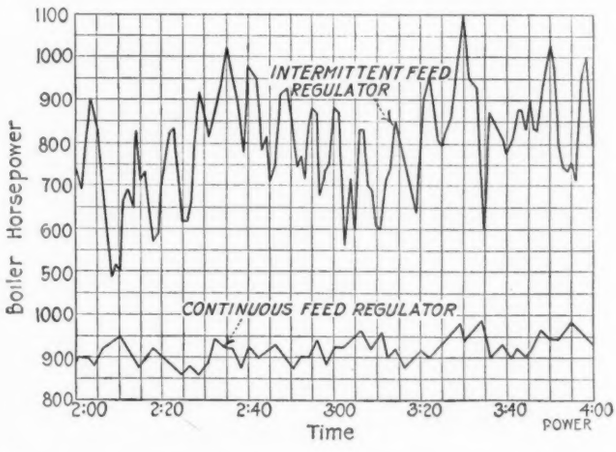


Fig. 2. Charts Comparing Intermittent and Continuous Feed

of heated water to draw upon at the time of greatest demand. When the load is light, the water level rises, and a considerable amount of extra water is heated up ready for increasing demand.

The float chamber is fitted with gage cocks and water glass, thus serving as a water column, and may be fitted with high- and low-water alarms if desired. Fig. 2 shows diagrams from the same boiler when controlled by regulators of the continuous- and intermittent-flow type.

To Repair Small Leaks in Lead Pipes, place the point of a dull tool or nail over the leak, give it a gentle tap with a hammer and the flow will cease.

Editorials

Engineers' License and Boiler-Inspection Laws

With September the annual struggle for legislation which shall reduce the loss of life and property from boiler and other power-plant accidents will begin under perhaps the most auspicious circumstances and with more numerous and potent influences operating in its favor than ever before.

On the first three days of the month the annual convention of the American Boiler Manufacturers' Association is to be held in New York. Wednesday will be devoted to a discussion of boiler legislation and uniform specifications. The Association is committed to the furtherance of uniform inspection laws, the members are interested in having such laws right, and there is little doubt that the discussion of such laws will be an important feature of the meeting.

During the second week the annual convention of the National Association of Stationary Engineers will be held in Milwaukee. This association, through a national committee and various local organizations, is working for the passage of laws providing for the examination and licensing of engineers. The report of the national committee, the discussion of results accomplished and the planning and providing for the work of the coming year should be helpful and inspiring. An organization of upward of twenty thousand men, even if they are scattered over forty odd states, ought to have some weight with the lawmakers if their influence is properly directed.

And then on the fifteenth there is to be held in the Engineering Societies Building in New York, under the auspices of a committee of the American Society of Mechanical Engineers, a hearing upon the form of law and code of boiler rules, which that committee recommends for universal adoption. The law properly provides for inspecting the personnel as well as the apparatus, for the best boiler ever made can be exploded by a careless or ignorant attendant, and the better the boiler the more disastrous is the explosion liable to be. The acknowledgement by a great national professional society like the Mechanical Engineers that the necessity for such legislation exists ought to insure intelligent attention to the measures, based upon the committee's report, which will be submitted to the various legislatures during the coming winter; and once the necessity or desirability of such legislation is admitted, the argument for the adoption of a uniform law which embodies the concrete wisdom of the best engineers and specialists of the country appears to be invincible.

For over thirty years POWER has been urging the passage of such laws not only in its columns but by argument before legislative committees, appeals to influential employers and other activities. Progress has been slow. The "Let us alone" policy has prevailed because those who wanted to be let alone had a bigger hand in the making and operating of legislatures than did the public whose safety was involved. But with a growing recognition of the importance of industrial losses, with all the significance attached to the slogan Safety First and with such sponsors as those above mentioned, American legislation for this purpose must come eventually if late.

Supervision of School Heating and Ventilating

The board of education of New York City is considering the advisability of placing engineering matters connected with public-school buildings under the direction of an engineering bureau, as mentioned on page 326. Inasmuch as the legislatures of most of the states have made it mandatory on school authorities to provide adequate facilities for heating and ventilating this class of public buildings, it may surprise the average layman to learn that the equipping and operating of these important engineering features of school buildings of the metropolis, instead of being supervised and controlled by trained and experienced heating and ventilating engineers, are under the authority and direction of architects acting as deputy superintendents of school buildings of the five boroughs.

This way of conducting so important a branch of school work seems to be a relic of the days when the highest aims of schoolhouse construction were satisfied by artistic design and ample seating capacity and when the profession of heating and ventilating was unknown. Few architects, however, who are entrusted with the construction of buildings wherein these features are of serious importance, feel qualified to work out their problems without the guidance of specialists. Even then, too often, the operative appointments are made to so far subserve architectural impressions that small opportunity is afforded the heating and ventilating engineer to design a system that can be operated with certainty and efficiency.

No matter how creditable the design, a heating and ventilating apparatus cannot take care of itself. Time and again, good designs have been condemned for want of expert supervision; numerous ventilating systems of hospitals, schools, and other public buildings have been pronounced failures where ample provisions had been made for ideal atmospheric conditions. In nearly every instance failure was due to subsequent architectural limitations or an absence of skillful technical guidance in their operation.

The problem confronting engineers has been to provide systems that could not be abused rather than those capable of the most successful operation. If managers of schools wish a fair return for their investment in heating and ventilating apparatus, the least they can provide is expert supervision, and they should take that intelligent view of the situation which it is believed the board of education of New York City will take in placing the heating and ventilating of school buildings in all branches of design and operation under the supervision and control of a heating and ventilating bureau.

Book Knowledge Theoretical?

Is all knowledge gained from books merely theoretical knowledge? Many of the questioning remarks heard in the nooks and crannies of the industrial world about the value of theoretical knowledge in the power plant, lead one to suspect the existence of a more or less widespread misunderstanding on this point. A power-plant engineer speaks with apparent pride of having got by experience all his knowledge of power plants and their operation and speaks slightingly of the knowledge another man professes to have gained by the reading and study of books. His own he calls "practical" knowledge, the other man's he calls "theoretical" knowledge, if indeed he admits that it is knowledge. Let us take a look into this question from another viewpoint.

The North American Indian bothered his head very little about what we sometimes call "theories." When he and his squaw and papoose needed shelter, he set up a few poles of various lengths in such a manner as to form a cone-shaped frame (although perhaps he did not try to coin a word to describe the shape), and then without yardstick or rule, or without making any attempt to calculate the number of pelts required, the red man used his bow and arrows on the beasts of the forest until he had bagged enough of their skins to cover the frame of his wigwam. With no thought or care about measurements or proportions this primitive man builds a house which has dimensions—height, diameter, circumference—builds it on such lines as to make sure it will shed rain and emit the smoke from his fire through an opening in the top. It was, after all, then, built according to a "theory," even though that theory had never been recorded in rude characters on birch bark, but had been handed down in the traditions of his tribe. Only among men of more highly developed mental faculties, who construct larger and more elaborately finished dwellings than did the Indian, do we find the work of construction carried on in accordance with certain laws regarding proportion, protection from weather, heating and ventilation, convenience, acoustics, etc. (And perhaps somewhere in the woods we might find "practical" builders who would call these laws and principles "theories.")

And during the centuries that intelligent men have been building houses, so many good ideas and valuable facts about building for better service have been discovered that no one man can remember them all, or hand them down safely by the mouth-to-ear plan. Hence, builders have set down in writing what they discovered or learned by experience, and this information has been gathered and published in book form. As each new generation of builders grows up and begins work, the wiser men among them read these books, get from them, in three or four years, practically all their forefathers knew about the subject, and then start in about where the men of the former generation left off in the art of building. Of course, some of the beginners push aside this "book knowledge," because they consider it "theoretical" and "impractical." These men refuse to profit by the experience of their forefathers and in consequence build less desirable houses than did their fathers. If you want proof, just look around any community and see how many badly designed and poorly constructed houses there are, and how few well designed and well built. What many men call "theories" about building are simply statements of the laws or rules that builders have found it well to observe in the construction of houses. The "theories" are based upon "practice."

The same principle and rule apply to engineering. All that is written above about learning to build houses better by reading books on building houses is equally true of power-plant engineering. The engineer is not wasting time—he is saving time—by reading books on his branch of work, provided he selects the right books. Some men have failed to recognize the difference in books. It is true that some books are mere efforts to expound hypotheses. But other books are accurate records of actual experiences and demonstrated facts. These last-mentioned books are not theoretical, in the strict sense of that word. They are intensely practical. The trouble is that we have got into the habit of classing as "theoretical" whatever is written. This is a mistake. The thing that drove some men to writing books was the discovery of many facts—multitudes of facts—so many facts that no man could remember them all and hand them on to other men by word of mouth. Books written for the purpose of recording and conveying such information are not merely theoretical and should not be discounted. They are authentic records of past practical experience and discovery by experiment. They should be read and duly credited. They form the bridge over the chasm of doubt on their subjects. They provide the true "short cut" from ignorance to practical and workable knowledge. They place the reader years in advance of his fellows who tie themselves to their own experience or observation for getting knowledge. They provide a groundwork for real experience that is truly useful and valuable. They give us the chance to avail ourselves of the accumulated knowledge of the past generations. They enable us to profit by and to enjoy the fruits of our forefathers' labor.

Let us get straight this question of what is really "theory" and what in contrast is the record of practice, and then, instead of robbing ourselves by a mistaken conception, we shall profit immensely by using the knowledge gained by our ancestors at such enormous cost.

⁂

If anyone has overlooked the cartoon and happens to wonder at the amount of matter relating to Milwaukee in this issue, we would hasten to explain that the National Association of Stationary Engineers will hold its annual convention in that city, September 7 to 12. For the benefit of those who will attend the meeting, a number of places of special interest to engineers have been referred to including Milwaukee's largest power plant, the Commerce Street station of the Milwaukee Electric Railway & Light Co., page 290; the Schlitz Brewery Plants, page 322; and the several other plants covered under the general title "Plants of Interest in Milwaukee," page 301. Those who are not going to the meeting may especially want to read the Milwaukee articles as they will not have the opportunity of seeing the places described.

⁂

If you do not record the coal consumption and entire output, you can never know how much steam can pass through a small hole.

Correspondence

Changing from 440 to 220 Volts

Answering the question of M. F. on p. 145, July 28 issue, the accompanying diagrams show changes made on two G. E. 440-volt three-phase induction motors to adapt them for service on 220 volts.

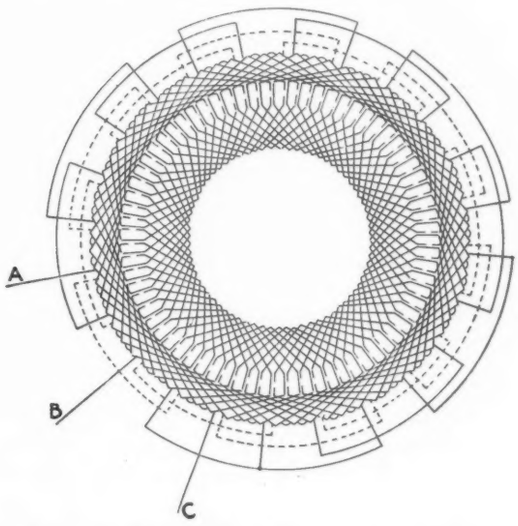


FIG. 1. SERIES-STAR WINDING FOR 440 VOLTS

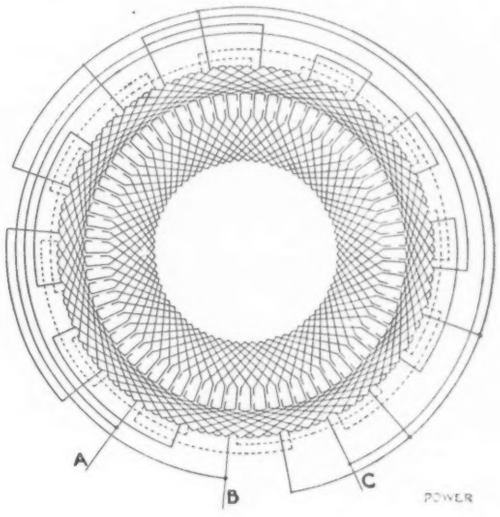


FIG. 2. TWO-CIRCUIT STAR WINDING FOR 220 VOLTS

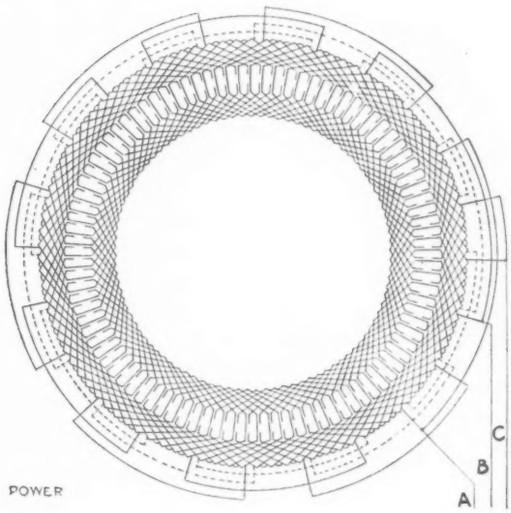


FIG. 3. SERIES-DELTA WINDING FOR 440 VOLTS

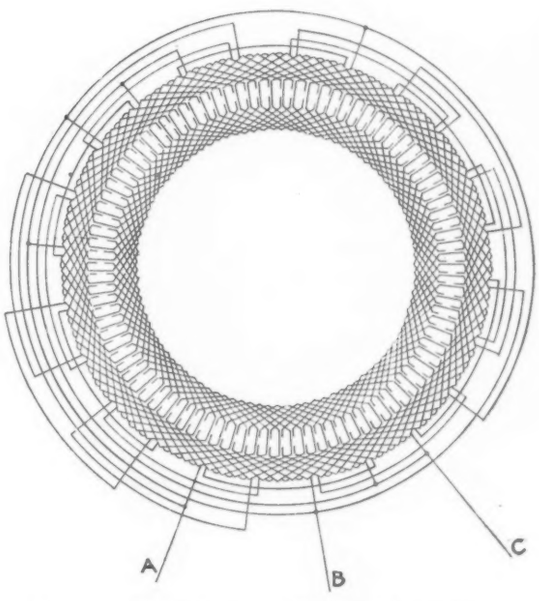


FIG. 4. TWO-CIRCUIT DELTA WINDING FOR 220 VOLTS

The motor shown in Fig. 1 had a series-star-connected stator. The end connections between the groups of coils were unsoldered and reconnected two-circuit star as shown in Fig. 2. This will be readily seen by tracing out the windings for each phase, starting at *A*, *B* and *C*.

Fig. 3 shows a series-delta-connected stator. The end connections were rearranged as shown in Fig. 4, and both motors operated very satisfactorily with the changed connections.

In a 440-volt motor the groups of coils between phases are as a rule connected in series. If such is the case, it is only necessary to reconnect the groups in two parallel

series circuits between phases to make them suitable for operation on half the original voltage.

P. JUSTUS.

Cleveland, Ohio.

To change a three-phase, 440-volt induction motor for 220-volt service, first find out the number of coils per phase per pole in the stator winding. If the number per pole is exactly divisible by 2, then each pole winding is easily separated exactly in the middle. These two windings are then connected in parallel with the interconnecting leads tapped to the same coils as before. Care must be taken to see that the parallel leads are similarly connected on every pole and that all interconnections remain as before. The revolutions per minute will practically remain as before, with similar load conditions.

BEN DAWSON.

Cedar Rapids, Ia.

Correcting Defect in Breeching Design

Occasionally, a good piece of power-plant apparatus fails of satisfaction because of the faulty design of the other apparatus with which it is connected. A case was brought to the writer's attention when asked to investigate the cause of an excessive amount of carbon in the refuse at a stoker-fired plant. This boiler plant is at a cement mill in the Middle West and uses coal mined in southeastern Kansas. The steam-generating plant consists of six 300-hp. water-tube boilers set in three batteries. Four of the units are equipped with chain grates, each having 72 sq.ft. of grate area and the other two, not being required, are disconnected from the breaching and all the steam lines.

For several years, the plant was oil fired, but this proved expensive on account of the price of oil prevailing at that time and because of the frequent renewal of the brickwork. The boilers were equipped with standard Bonus type baffles and the gases passed through an underground tunnel below the rear of the boilers to a stack outside the boiler room. At the time stokers were installed, the boiler baffles were changed to the horizontal type, as shown in Fig. 1, and a new breaching was constructed above the boilers and connected to a 175-ft. steel stack.

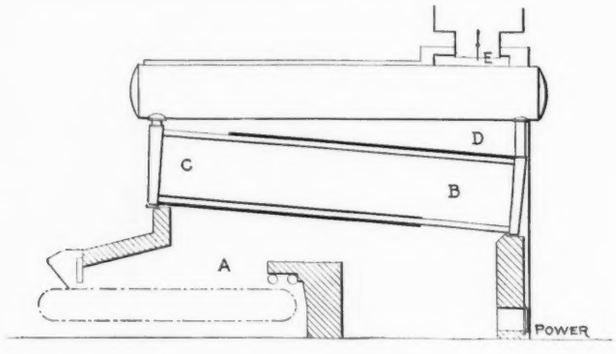


FIG. 1. SHOWING POINTS AT WHICH DRAFT WAS MEASURED

The stoker manufacturer had guaranteed to develop 130 per cent. boiler rating based on 10 sq.ft. of heating surface per horsepower and to secure a combined efficiency of boiler, furnace and grate of 68 per cent. For the performance of this guarantee, it was stipulated that the coal should contain at least 10,500 B.t.u. per pound as fired and that the furnace draft should be equivalent to 0.3 in. of water. It was reasonable to expect this intensity of draft with normal conditions, but a series of draft readings (Table 1) showed an abnormal loss at the rear drum pass and as a result the furnace draft was low. Internal inspection of the cold setting at once located the trouble. It appeared that in changing the brickwork, the proportioning of gas passages had been left to the judgment of the bricklayers. The openings where the gases pass upward about the drums to the uptake had been built as shown by the dotted lines in Fig. 2, thus giving a total area of only 5.5 sq.ft. Consequently it was necessary to tear down part of the brickwork and increase these areas by corbelling back as shown by the full lines, thus securing an area of 12.7 sq.ft.

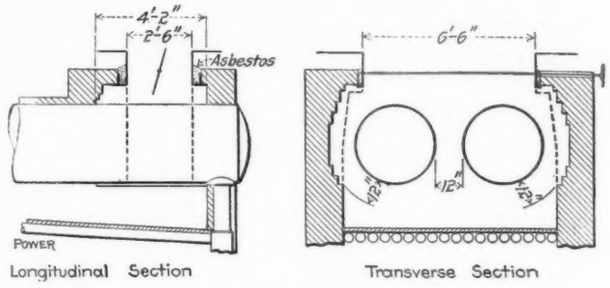


FIG. 2. DOTTED LINES REPRESENT CONTRACTED UPTAKE AND SOLID LINES THAT AFTER CORBELLING

TABLE I

Point of Observation	Intensity of Draft, Inches of Water Before Correcting Defect	After Correcting Defect
A	0.18	0.35
B	0.25	0.38
C	0.38	0.45
D	0.49	0.64
E	1.05	0.85

The original net areas at various points (Fig. 1) in the path of the gases and the corresponding areas after making the change are given in Table 2. Table 1 shows the draft readings taken before and after making the changes, all readings having been taken with a 5¼-in. fire, with the grates completely covered and with the boiler damper wide open. The CO_2 just below the damper averaged 10 per cent. After slightly reducing the opening between the waterback and the grate and operating with the increased draft, the coal was burned out to satisfactory ash and the boilers easily generated the over-rating specified.

TABLE II

Passage	Area in Square Feet Before Correcting Defect	After Correcting Defect
Grate surface	71.3	71.3
Over bridgewall	22.0	22.0
Lower baffle opening	15.0	15.0
Around tubes between upper and lower baffle	16.4	16.4
Upper baffle opening	8.75	10.6
Between drum and top of upper baffle	12.0	12.0
At sides and between drums at the rear	5.5	12.7
Damper	16.2	16.2

Such mistakes sometimes occur because of the inexperience of the designer, and it is a good plan always to ask the advice of the builders of a piece of apparatus

before attempting to make radical changes. In the above case, considerable expense could have been saved, though fortunately there was no interference with the operation of the plant, as the mistake was discovered before the machinery was ready for continuous running.

It is well to remember that gas passages should be so proportioned that the velocity does not exceed 40 ft. per second when the maximum capacity is developed and, in cases like the above, where the passage is divided into three parts, the velocity should be lower. It is estimated that the velocity in the present case will average about 30 ft. per second when operating at maximum rating.

W. M. PARK.

Fort Worth, Texas.

Voltage Combinations

Answering C. D.'s inquiry in POWER for July 28, page 145, the following sketches show the method of obtaining simultaneously 110-220-volt, three-phase, three-wire, and 110-220-volt, single-phase, three-wire service from one set of standard 2300-volt primary, 110-220-volt secondary, single-phase transformers connected to a 2300-volt, three-phase, three-wire primary line. The theme is an interesting one to a student of polyphase currents and has been developed with the view of showing what could be accomplished if necessary rather than what should be done.

In accordance with the request, two cases are considered, an open and a closed one. Two sketches are shown for each case, one showing the transformer connections and the other the phase relations by the conventional method, the inner lines representing the primary and the outer lines the secondary windings; moreover, the lettering is consistent throughout, capital letters designating the primary lines and small letters the secondary circuits.

CASE I—Two transformers with primaries and secondaries in open delta, giving a five-wire secondary with five circuits, as follows:

One 220-volt, three-phase, three-wire, lines *a-b-c*.

One 110-volt, three-phase, three-wire, lines *d-b-e*.

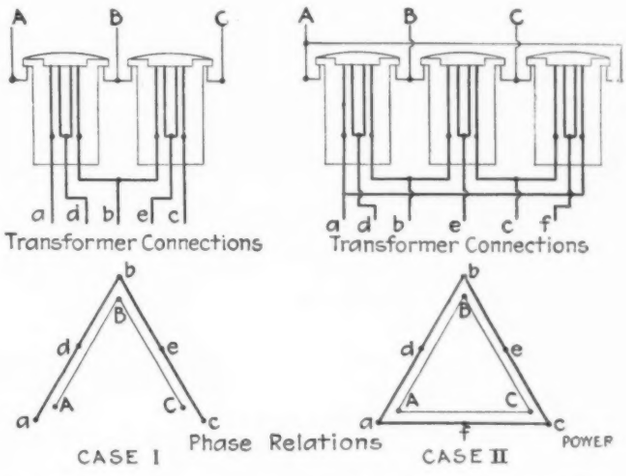
Two 110-220-volt, single-phase, three-wire, lines *a-d-b* and *b-e-c*.

One 220-volt, single-phase, two-wire, lines *a-c*.

This latter circuit may also be used for such 110-volt, single-phase devices as may be operated two-in-series on 220 volts.

The open-delta connection, while comparatively simple, has several disadvantages. A balanced load will not be obtainable, the best condition being with the 110-220-volt, single-phase load (with the exception of such as may be used on circuit *a-c*) divided as nearly as possible into two equal circuits, well balanced as to the 110-volt devices, and these two circuits supplied by transformers *a-d-b* and *b-e-c*. Even under these conditions, that portion of the secondary windings included between *d-b* and *b-e* will carry the greatest load.

The transformers should be selected with a rating in kv.-a. not less than 220 times the sum of the ampere ratings of all the three-phase devices, plus the sum of the ampere ratings of the 220-volt, single-phase devices plus one-half the sum of the ampere ratings of the 110-volt, single-phase devices. Ample transformer capacity should be provided as an insurance against interruptions due to burnouts, the loss of either transformer entailing the interruption of four out of the five circuits, all except the 110-220-volt, single-phase circuit from the remaining transformer.



TRANSFORMER CONNECTIONS FOR DESIRED VOLTAGE COMBINATIONS

Line wire *b* should be of ample cross-section, as this is a part of all circuits except the 220-volt, single-phase circuit *a-c*.

CASE II—Three transformers with the primaries and secondaries in closed delta, giving a six-wire main with eight circuits, as follows:

One 220-volt, three-phase, three-wire, lines *a-b-c*.

Four 110-volt, three-phase, three-wire, lines *a-d-f*, *b-e-d*, *c-f-e*, *d-e-f*.

Three 110-220 volt, single-phase, three-wire, lines *a-d-b*, *be-c*, *c-f-a*.

While this method is not so simple as that of Case I, it permits the load to be more nearly balanced, the degree depending upon the relations of the various classes of load and the engineering skill used in apportioning the load between the several circuits. The burnout of one transformer in this case would result in the loss of three out of the four 110-volt, three-phase circuits completely and limit the usefulness of one of the 110-220-volt, single-phase circuits, producing the condition of Case I.

In practice, the various secondary wires should be consistently marked at all junctions and taps as an aid in time of trouble, and if the scheme of Case II is adopted, these markings would permit temporary connections to be made and thus reduce the time the apparatus would be out of commission due to line or transformer troubles.

The voltage regulation of an installation of this character would be influenced so much by local conditions of which no information is given that comment is withheld, except to say that with a delta-connected circuit independent regulation is possible on but two phases, the voltage on the remaining phase being the resultant of the other two. With sufficient copper in the primary and secondary mains, and ample transformer capacity, satisfactory conditions could probably be obtained.

R. ARTHUR JOSLYN.

Roxbury, Mass.

Engineers' Study Course

Elementary Mechanics--XXIV

LAST LESSON'S ANSWERS

106. From equation (59) $P = \frac{W \times H}{L}$. In this problem $W = 1600$ lb.; $H = 1$ ft.; and $L = 12$ ft. so that

$$P = \frac{1600 \times 1}{12} = 133\tfrac{1}{3}\ lb.$$

107. The horizontal force P necessary to hold the body at rest on the plane is $W \frac{\sin a}{\cos a} = W \tan a$. Since the plane rises 1 in 12 $\sin a = \frac{1}{12}$ or $a = 4$ deg. 47 min. Therefore the force

$P = 1600 \times \tan 4\ deg.\ 47\ min. = 1600 \times 0.0836 = 133.8\ lb.$

108. The force of friction F = the coefficient of friction f times the normal pressure, or

$F = f\ W \cos a = 0.18 \times 1600 \times 0.9965 = 0.18 \times 1594 = 287\ lb.$

The force of gravity tending to move the body down the plane is

$$W \sin a = 1600 \times 0.0833 = 133\ lb.$$

The force P necessary to prevent motion down the plane must equal the force of gravity minus the force of friction or,

$P = G - F = W \sin a - f\ W \cos a = 133 - 287 = -154\ lb.$

The fact that the value of P works out negative shows that under the given conditions the force of gravity is not sufficient to overcome the force of friction, so that to move the body down the plane an additional force P must be applied. (See answer to problem 110.)

109. For the body to be on the point of moving up the plane the force P must overcome both the force of gravity and the force of friction. From the previous problem the force of friction is 287 lb. and the force of gravity 133 lb. Therefore the force

$$P = F + G = 287 + 133 = 420\ lb.$$

Any value of P between -154 lb. and $+420$ lb. will hold the skid at rest on the plane.

110. The force P will act down the plane when the force of friction up the plane is greater than the force of gravity down the plane. This will occur when the tangent of the angle a is less than the coefficient of friction for it was shown in lesson XIV that when a body is just on the point of moving down a plane the coefficient of friction f is equal to the tangent of the angle made by the plane with the horizontal. (See solution of problem 108.)

INCLINED PLANE (CONTINUED)

As a final example under case II let the force P, Fig. 73, act parallel to the base of the plane, and assume that the body is on the point of moving up the plane, under which condition both the force of gravity and the force of friction will act down the plane, thus opposing the upward force which is the component of P parallel to the plane.

Resolve the horizontal force P into two components parallel to and at right angles to the plane by constructing the parallelogram $RMSGR$. The component RG, parallel to the plane will tend to move the body up the plane. The component SG will tend to increase the normal pressure between the weight and the plane, thus increasing the force of friction. Also resolve the weight W into two components parallel to and at right angles to the plane.

The force of gravity G, acting down the plane is equal to the component EF or $W \sin a$. The total normal pressure between the weight and the plane is the sum of the components SG and GF where

$$SG = MR = P \sin a$$

and

$$GF = W \cos a.$$

From equation (22) the force of friction F, acting down the plane is equal to the total normal pressure N, times the coefficient of friction f, or,

$$F = f \times N$$

where

$$N = SG + GF = P \sin a + W \cos a;$$

hence

$$F = f\ (P \sin a + W \cos a).$$

The effective force tending to move the body up the plane is the component of the force P parallel to the plane or RG which is equal to $P \cos a$. For equilibrium to exist, the forces F and G acting down the plane must equal the force RG, or $P \cos a$, acting up the plane, whence,

$$P \cos a = F + G$$

or

$$P \cos a = f\ (P \sin a + W \cos a) + W \sin a.$$

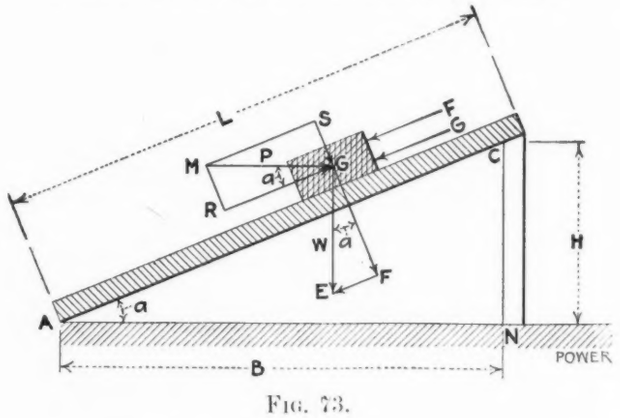


FIG. 73.

To find the relation between P and W, solve the above equation by collecting all the terms involving P, thus,

$$P \cos a - f\ P \sin a = f\ W \cos a + W \sin a$$

now divide both sides of the equation by $\cos a$, then

$$\frac{P \cos a}{\cos a} - \frac{f P \sin a}{\cos a} = \frac{f W \cos a}{\cos a} + \frac{W \sin a}{\cos a},\ or,$$

$$P - f P \frac{\sin a}{\cos a} = f W + W \frac{\sin a}{\cos a}\ \text{and}$$

$P\,(1 - f\,tan\,a) = W\,(f + tan\,a)$, since $\frac{sin\,a}{cos\,a} = tan\,a$, therefore

$$P = W\left(\frac{f + tan\,a}{1 - f\,tan\,a}\right) \qquad (64)$$

When the weight W is on the point of moving down the plane then the force of friction will act up the plane or,

$$G = P\,cos\,a + F$$

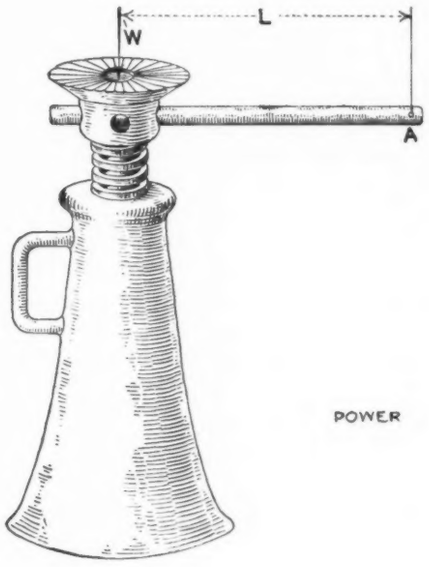


FIG. 74.

$$W\,sin\,a = P\,cos\,a + f\,(P\,sin\,a + W\,cos\,a)$$

and

$$P\,cos\,a + f\,P\,sin\,a = W\,sin\,a - f\,W\,cos\,a$$

hence, dividing through by $cos\,a$,

$$P + f\,P\,tan\,a = W\,tan\,a - f\,W$$

or

$$P = W\,\frac{tan\,a - f}{1 + f\,tan\,a} \qquad (65)$$

Any value of P between those given by equations (64) and (65) will hold the body at rest on the plane.

The efficiency of the inclined plane as a machine for the performance of useful work may be readily determined. In Fig. 73, when the weight has moved from A to C, the useful work performed is just the same as if the weight W had been raised in a vertical direction from the point N to the point C. Hence the net result of sliding the weight up the plane is the overcoming of a resistance of W lb. through a vertical distance of H ft. or the output of the machine is $W \times H$.

The work done on the body by the force P in moving the body up the plane is $P\,cos\,a$ (resistance) times L (distance); but $L\,cos\,a = B$ (the base of the plane), therefore the input $= P \times B$.

From equation (53) $efficiency = \frac{output}{input}$.

Let E = the efficiency of the inclined plane whose slope is a deg., then, $E = \frac{output}{input} = \frac{W \times H}{P \times B}$ but $\frac{H}{B} = tan\,a$ and $P = W\left(\frac{f + tan\,a}{1 - f\,tan\,a}\right)$ hence

$$E = \frac{W\,tan\,a}{W\left(\frac{f + tan\,a}{1 - f\,tan\,a}\right)} = \frac{tan\,a\,(1 - f\,tan\,a)}{f + tan\,a}$$

The above equation may be simplified by dividing numerator and denominator by $tan\,a$, thus, $E = \frac{1 - f\,tan\,a}{\left(\frac{f}{tan\,a}\right) + 1}$, or,

$$E = \frac{1 - f\,tan\,a}{1 + f\,cot\,a} \qquad (66)$$

(Note: $\frac{1}{tan\,a} = cot\,a$. See lesson III in Trigonometry).

Equation (66) is useful in determining the efficiency of a screw jack, a screw press or the efficiency of screw threads.

Turning a nut on a rod on which a thread has been cut is just the same as moving a body up an inclined plane by the aid of a horizontal force. The height of the plane NC, Fig. 73, corresponds to the pitch of the thread, the length L is the development of the thread, and the base B is the circumference of the bar on which the thread is cut. The inclination of the plane is the angle of the thread.

Example—The angle of a given screw thread is 6 deg. The coefficient of friction between the nut and the thread is 0.15. Find the efficiency of the screw. In this case

$$tan\,a = tan\,6\ deg. = 0.105$$

and

$$cot\,6\ deg. = 9.514$$

Substituting these values in equation (66), there results:

$$E = \frac{1 - f\,tan\,a}{1 + f\,cot\,a} = \frac{1 - (0.15 \times 0.105)}{1 + (0.15 \times 9.514)} = \frac{0.984}{2.427}$$

$$= 40.5\ per\ cent.$$

STUDY QUESTIONS

111. In the screw jack shown in Fig. 74, there are four threads per inch and the diameter of the screw is 2 in. Assuming the coefficient of friction as 0.14, find the efficiency of the jack.

112. A man exerts a pressure of 40 lb. at the point A, located 24 in. from the center of the jack. Find the maximum weight W that he can raise, neglecting the inertia of the weight.

113. A loaded coal car weighing 2000 lb. starts down an incline whose slope is 1 in 18. If the frictional resistance is 20 lb. per ton, find the acceleration with which the car will move down the plane.

114. If the plane is 500 ft. long, find the velocity of the car when it reaches the foot of the incline.

115. How far will the car run on the level before coming to rest. [Figure the kinetic energy of the car when it reaches the foot of the incline and then find the distance from equation (57).]

CORRECTION—In the statement of question 96, Lesson XXI, Aug. 11, 1914, "a pressure of 120 lb. per sq.in." should have read "a head of 120 ft." The answer given in the next lesson would then be correct. As it was stated, the answer should be 2.3 times that given, or

$$2.3 \times 30.3 = 69.69\ hp.$$

since 1 lb. pressure = 2.3 ft. head.

The answer to question 98, Lesson XXII, Aug. 18, 1914, was in error in that it did not take account of the 75 per cent. efficiency assumed between the engine and the load. The answer should be

$$\frac{3\frac{1}{3}}{0.75} = 4\frac{4}{9}\ hp.$$

At best the problem does not admit of an exact practical answer, as explained in the paragraph following the answer given.

Inquiries of General Interest

Temperature of Superheated Steam—What would be the temperature of steam at 150 lb. gage pressure superheated 250 deg.?

R. J.

The temperature of dry-saturated steam at 150 lb. gage pressure being 366 deg. F., when superheated 250 deg., the temperature would be 366 + 250 = 616 deg. F.

Safety of Flywheel—If the centrifugal force which tends to burst a flywheel rim is directly proportional to its weight, why is it that increasing the size of the rim would not increase the danger of rupture?

D. J.

Because the cross-sectional area, and consequently the strength of the rim, would be increased in direct proportion with the increase of weight.

Della Porta—Who was della Porta and what connection had he with the development of the steam engine?

S. D.

Giambattista della Porta (1543-1615) was an Italian physicist who published, A. D. 1601, a treatise in which he shows an apparatus similar to Hero's fountain, but with steam in place of air as the displacing fluid. His suggestions fully anticipate the engine which a century later was developed by Savery as the earliest commercially successful steam engine.

Filtering Air for Indirect Heating—How can dust be prevented from being carried into buildings which are heated by indirect blower systems?

R. M.

The fresh air should be taken into a settling chamber and thence drawn through a number of screens of heavy cheesecloth. The screens should be spaced several feet apart and have from five to ten times the area of the supply ducts, so that the air may pass through the screens at low velocity. The settling chamber and screens should frequently be cleaned.

Length of Belt Splices—What is the proper length for splicing joints of single and double leather belts, 4 to 18 in. wide?

G. H. L.

Most manufacturers make the scarf length equal the belt width for all single and double belts, down to 5 in. wide; and for belts of less than that width make the scarf about 1 in. longer than the belt width. Double belts over 10 in. wide should have the scarf ends each covered with a tuck or dovetail, formed by a narrow overlap of the corresponding thickness of the opposite end of the belt.

Oil in Condensate—How can the presence of oil in return water from exhaust steam heating be determined?

P. M. R.

A fair test of the amount of engine cylinder oil contained in a sample of condensation may be made by determining how much oil has to be added to a given quantity of fresh water to cause the latter to present the same appearance of turbidity when equal quantities of each kind of water are mixed with the same quantity of any given solution of sodium hydrate (caustic soda). Care should be taken that all solutions are employed at the same temperature.

Effect of Clearance on Mean Effective Pressure—For a given point of cutoff, what effect has the cylinder clearance on the resulting mean effective pressure?

P. M. G.

Clearance has the effect of increasing the mean effective pressure by increasing the mean forward pressure and decreasing the mean back pressure. This is because steam which expands after cutoff includes that which fills the clearance space; hence the greater the percentage of clearance the greater the average forward pressure; and on the return stroke, as the amount of compression is inversely as the volume, the average back pressure will be less the greater the percentage of clearance.

Advantages of Centrifugal Pumps—What are the advantages of centrifugal over reciprocating pumps, and more especially as boiler feeders?

W. B.

The leading advantages of centrifugal pumps are compactness, silent running, durability and superior economy in cost of power, attendance and repairs, and the facility with which they may be adapted to any location where they may be supplied with power by direct connection to an electric motor or steam turbine. As boiler feeders, they have the advantage over reciprocating pumps of continuous delivery without shock or hammering, and of producing no excessive pressure on feed mains for any adjustment of feed stop valves or other stoppage of pipe connections.

Water Horsepower—What would be the water horsepower in pumping at the rate of 200 gal. of water per minute against a pressure of 80 lb. per sq.in.?

R. B.

Taking the weight of 1 gal. of water as 8⅓ lb., the weight of water pumped per minute would be

$$200 \times 8\tfrac{1}{3} = 1666.66 \text{ lb.}$$

A pressure of 1 lb. per sq.in. is equivalent to the pressure created by a column of water 2.309 ft. high and pumping against 80 lb. pressure would be equivalent to pumping against a head of $2.309 \times 80 = 184.72$ ft., or raising the water to that height. The energy developed would be

$$1666.66 \times 184.72 = 307{,}865.43 \text{ ft.-lb. per min.}$$

or

$$\frac{307{,}865.43}{33{,}000} = 9.33 \text{ hp.}$$

Dimensions of Cylinder—If the volume of a cylinder is 11.78 cu.ft. and its length is 2½ times its diameter, what would be the diameter and the length?

J. J. F.

If

d = The diameter in feet, and
l = The length of the cylinder,

then as the cross-sectional area would be

$$d^2 \times 0.7854,$$

the volume would be

$$d^2 \times 0.7854 \times l.$$

As $l = 2\frac{1}{2}\ d$, and the given volume is 11.78 cu.ft. then

$$d^2 \times 0.7854 \times 2\frac{1}{2}\ d = 11.78 \text{ cu.ft.},$$

from which we find

$$d^3 = 5.999 \text{ and}$$

$$d = \sqrt[3]{5.999} = 1.817 \text{ ft.},$$

and the length would be

$$2\frac{1}{2} \times 1.817 = 4.542 \text{ ft.}$$

Formula for Shafting—What is the rule for estimating the safe number of horsepower transmitted by iron or steel shafting when properly lined up and supported?

B. F. A.

The safe transmitting capacity of a 1⅞- or nominal 2-in. diameter shaft, with the usual bending strains of pulleys, belts, etc., is 10 hp. at 100 r.p.m. The torsional resistances of shafts are as the cubes of their diameters, and the number of horsepower transmitted by any given size is directly in proportion to its speed of rotation. Hence for finding the power capable of being transmitted by any size shaft at any number of revolutions per minute: Multiply the cube of its diameter in inches by the revolutions per minute and by 10 and divide by the cube of 2, multiplied by 100; or expressed in a formula wherein

d = diameter of shaft;
n = number of revolutions per minute;

$$\frac{d^3 \times n \times 10}{2 \times 2 \times 2 \times 100} \text{ or } \frac{d^3 n}{80} = \text{hp.}$$

For example, the safe number or horsepower which a 3-in. shaft, running at 200 r.p.m., could transmit would be

$$\frac{(3 \times 3 \times 3) \times 200}{80} = 67.5 \text{ hp.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Nordberg Oil Engine

An oil engine for general power-plant purposes, irrigation, etc., has just been perfected by the Nordberg Mfg. Co., of Milwaukee. It is of the single-acting two-stroke-cycle type and of heavy construction, as may be seen from Fig. 1. The crank end is of steam-engine design, that is, the engine is provided with a crosshead having adjustable babbitted shoes and a standard Nordberg wristpin. The crankpin bearing is of the marine type and all moving parts are counterbalanced.

Simplicity has been the keynote of the design, there being no valves except one for admitting scavenging air, so that the usual valve gear is lacking. Ignition is effected by the heat of compression, and the fuel supply is controlled by the governor. The clearance space is almost semispherical and the cylinder and cylinder head are thoroughly water-jacketed.

As shown in Fig. 2, the crank end of the cylinder is inclosed and a stuffing box is provided for the piston rod. Air for scavenging is drawn into this space on the back stroke of the piston, through a piston valve mechanically operated by an eccentric on the main shaft. Mechanical control permits a later closing of the valve, so that more air will be drawn in by the piston. On the forward stroke this air is compressed and through the bypass over the top of the cylinder is admitted to the combustion chamber when the piston uncovers the transfer port *A*. The volume of the bypass may be varied slightly to obtain the desired pressure. When the port is uncovered the air sweeps into the cylinder and is deflected so that it forces the burned gases through the exhaust port *B* at the bottom of the cylinder. On the return stroke the fresh air remaining is compressed to about 450 pounds.

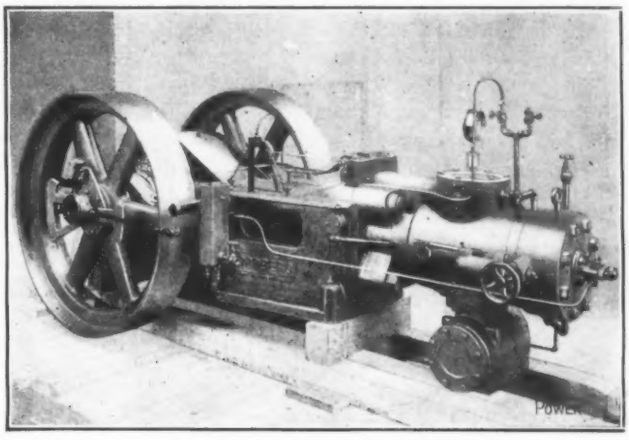


FIG. 1. GENERAL VIEW OF NORDBERG OIL ENGINE

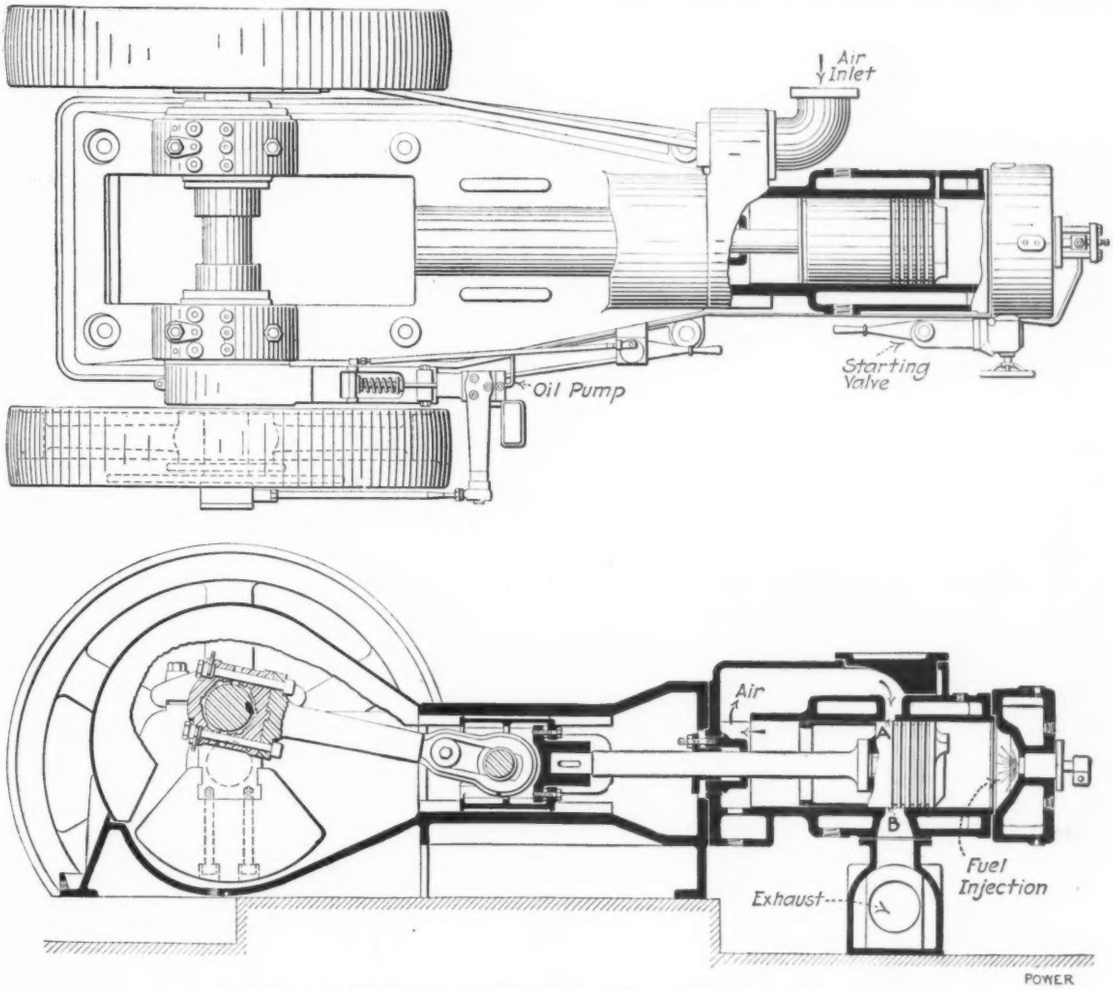


FIG. 2. PLAN AND SECTION OF NORDBERG OIL ENGINE

Near the end of this stroke a quantity of oil, determined by the governor, is injected by a pump through a fine nozzle and distributing device into the cylinder. The pump, which is of the plunger type, has a constant

stroke. Consequently on every suction stroke it draws in the same quantity of oil. During discharge, however, part of the oil is returned to the suction through a by-pass valve, its opening point being determined by the governor. On the pressure stroke the pump is positively driven by an eccentric on the main shaft and a cam which comes in contact with the plunger. The return stroke of the pump is effected by means of a spring; see Fig. 1.

An inertia flywheel governor of the pendulum type advances or retards an eccentric controlling the bypass valve of the oil pump. As little work is required of it, the governor is of light construction. A speed regulation to within two per cent. from no load to full load is claimed.

The engine is started in the usual way by compressed air, admitted through a spring-operated valve at the side of the cylinder. To insure against leakage when the engine is running, a hand-operated valve, shown in Fig. 1, is also provided. Lubrication is effected by a two-compartment positive feed pump having outlets to each bearing and one to the cylinder.

At present the engine is made in sizes from 50 to 100 hp., with speeds ranging from 270 to 300 r.p.m. Greater powers might, of course, be obtained by a duplication of cylinders.

The Schlitz Brewery Plants

By Thomas Wilson

SYNOPSIS—An outline of the mechanical equipment, with special reference to the new 150-ton plate ice plant. A 40-yr.-old poppet-valve engine is still doing good work.

The largest brewery in Milwaukee, and dispenser of the famous "beer in brown bottles," has many features of mechanical interest. The equipment for handling the product is of the latest and best, and large plants are required to furnish steam for the various processes, refrigeration for cooling and power to turn the wheels. There are two boiler plants, one having 3900 hp. and the other 2550 hp. in water-tube and return-tubular boilers.

The steam, which is generated at 125-lb. pressure, is used for manufacturing purposes, for heating (which is nearly all live steam) and for driving the engines connected to the ammonia compressors. In the latter department there is a total capacity of 1850 tons of refrigeration in seven units. The compressors are of the Linde type, driven by corliss engines, and two by a German Sulzer poppet-valve engine some 40 years old. The latter is in excellent condition and, from all appearances, is good for many years to come. The engine units are run condensing. Above the compressor room are ammonia condensers of the atmospheric type. Water for condensing is supplied by a pumping station on the

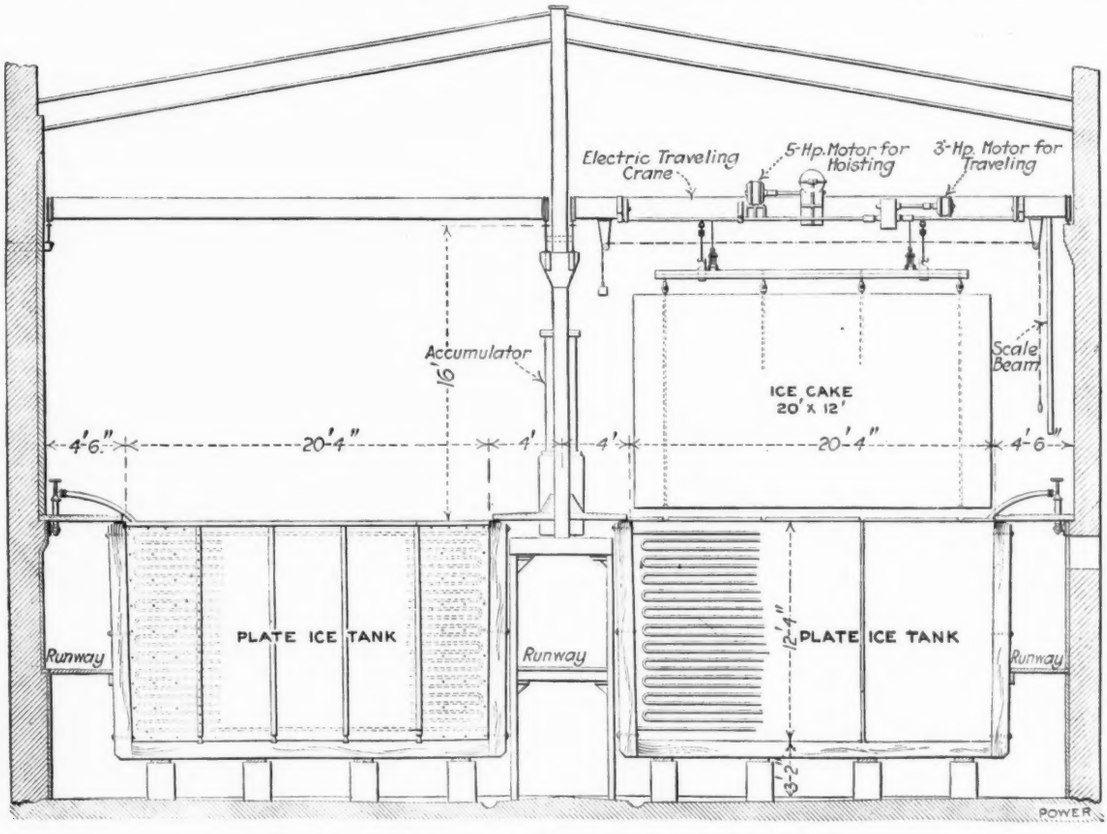


Fig. 1. Transverse Section of Plate Ice Plant

river three blocks distant. There is a 6-million-gal. pumping engine and a 7½-million-gal. centrifugal pump to supply a capacity demand of 3½ million gal. Steam for these units is superheated to 500 deg. The water is first supplied to the ammonia condensers and then passed on to condense the steam.

A total of 500 motors in the brewery, varying in size from ½ to 60 hp., and the lighting are supplied with current from the Commerce St. station of the Commonwealth Power Co. This station also supplies current to various company buildings and for outside commercial use. It will soon have a total capacity of 5500 kw., 2500 kw. in three cross-compound, alternating-current barometric condensing units, and a 3000-kw. turbine now being installed. There is 3000 hp. of water-tube boilers, with special facilities for unloading coal from boats and conveying it from storage to bunkers above the boilers.

Perhaps the most interesting and, at any rate, the latest addition to the mechanical equipment is the 150-ton Vilter plate ice plant; it is in operation the year around, making ice for refrigerating cars and local transportation at a cost not exceeding 70c. per ton. The building is 61x145 ft. and, to the roof trusses, is 36 ft. high. As shown in Figs. 1 and 2, it has two tanks, each 110 ft. 4 in. long, 12 ft. deep, 20 ft. wide at the bottom and 20 ft. 4 in. wide at the top. Three bulkheads divide each tank into four compartments, each containing 10 zigzag coils of 1¼-in. extra heavy pipe. A plate of ice 12x20 ft. and 11 to 12 in. thick forms on each side of a coil, so that the capacity of the plant in seven days, the freezing time, is 160 plates of ice, each weighing 6½ to 7 tons, a total of 1120 tons, or 160 tons per day of 24 hr. if the maximum weight per plate is assumed. Each coil has 475 lin.ft. of pipe and is covered on each side with a sheet-steel plate to facilitate the removal of the ice.

Water for ice making is obtained from wells on the premises 800 to 1600 ft. deep. It is fed into the compartment between the coils and kept in constant agitation by air compressed to 8- or 9-lb. pressure by either one of two motor-driven blowers. To each compartment there are two ½-in. nozzles supplying the air from the sides of the tank near the bottom. In forcing its way to the top, the air keeps the water in motion and frees it from the small quantity of air it usually contains. During the freezing process the impurities and suspended matter are constantly forced toward the center of the compartment and the water receiving the impurities between the two plates can be drawn off at the bottom.

After the plates have been frozen to the desired thickness they are allowed to temper for 6 to 8 hr. The next process is to free them from the steel plates covering the coils and the surfaces of the tank with which they come in contact. These coils are shut off from the low-pressure side and are fed with hot ammonia vapor direct from the compressor. As the vapor is under high pressure, about 175 lb., it forces the liquid ammonia in the coils into the low-pressure system. The coils are then full of hot vapor, and in condensing, this gives up its heat to the surrounding steel plates, which in the course of half an hour are freed from the ice. Steam coils are used to loosen the ice from the bottom and sides of the tank. For every two plates there are 150 ft. of 1-in. pipe. Between the supporting timbers the steam coils

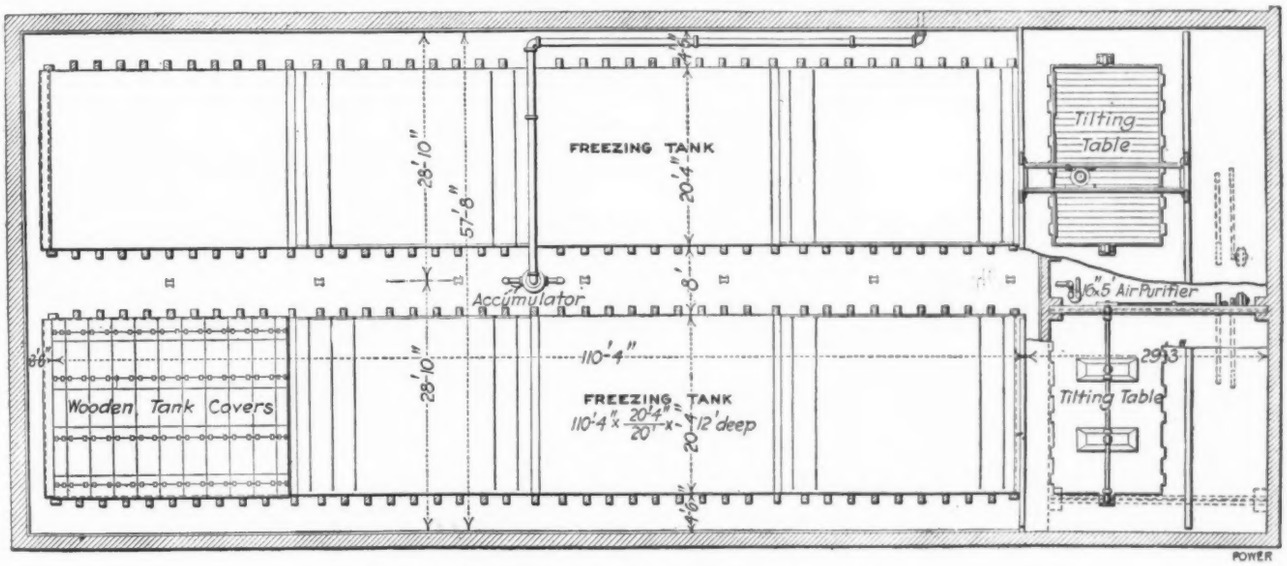


FIG. 2. PLAN VIEW, SHOWING GENERAL LAYOUT

are placed next to the ¼-in. steel wall of the tank and are covered with double boards.

When the plate is free, the ice is ready to be harvested. Four hollow tubes frozen into the plate and passing through it to the bottom of the ice afford means of attachment for the hooks of the traveling crane, which hang from a horizontal beam suspended by the hoisting cables of the crane. While suspended as in Fig. 3, the weight of the plate may be transferred to a beam scale and the tonnage recorded. The plate is then conveyed to a cutting table, which may be tilted, as in Fig. 4, to receive the ice, and then lowered to a horizontal position. The lifting rods are thawed out by steam, and the plate, in this plant, is cut into 77 pieces approximately 21 in. square. As shown in Fig. 5, the saw is mounted on a traveling frame kept in motion for the cuts in one direction. For the cross-cuts the saw carriage travels on the frame; the saw is, of course, adjustable to any size of cake. There is a 7½-ton crane and a cutting table for each tank. After the cakes are sawed they are conveyed to storage.

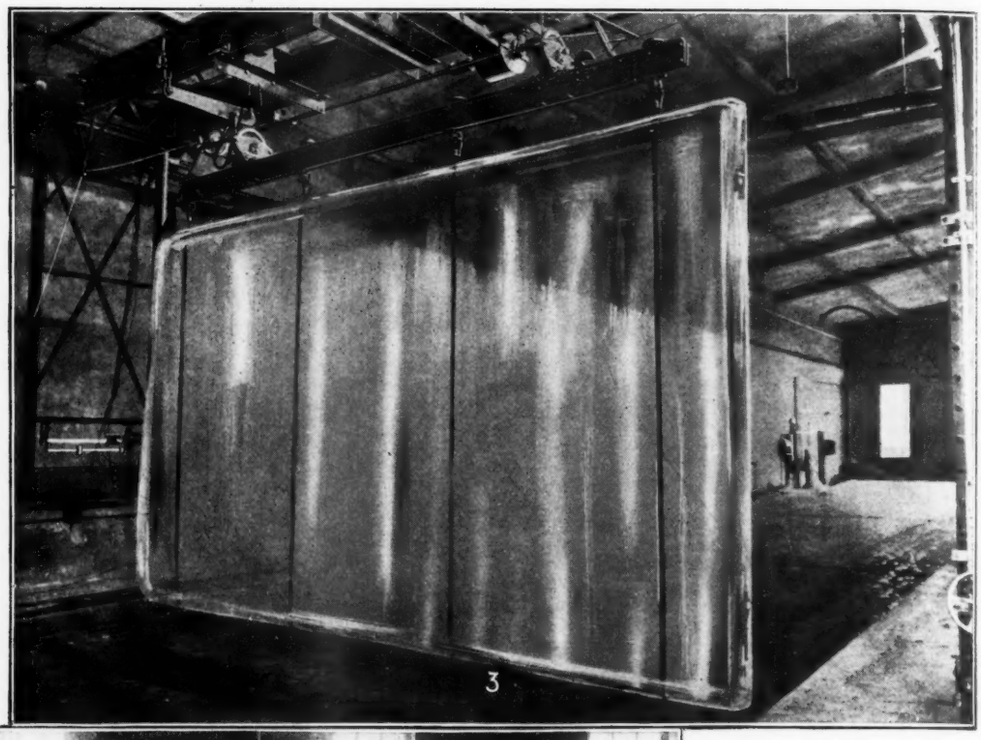


FIG. 3. PLATE OF ICE SUSPENDED FROM TRAVELING CRANE

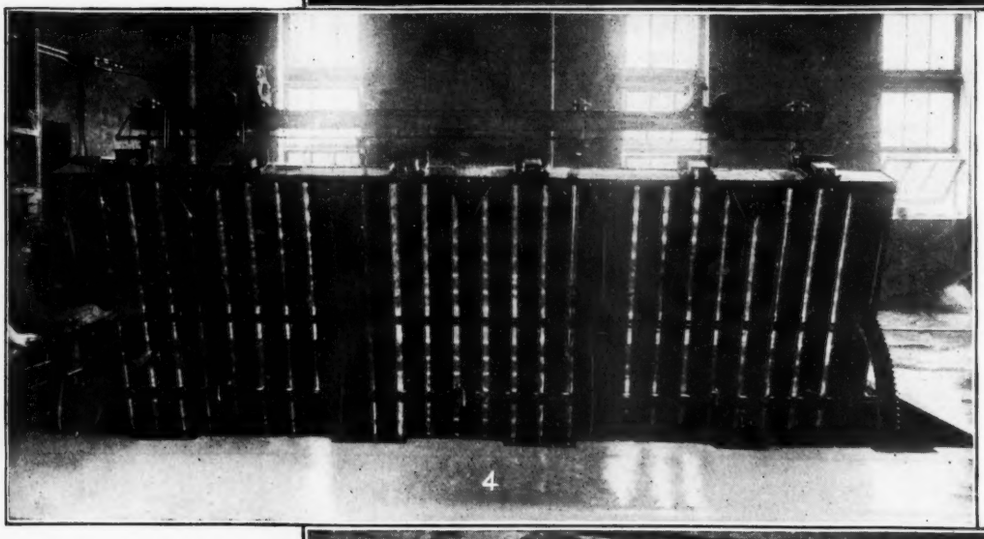


FIG. 4. CUTTING TABLE TILTED TO RECEIVE A PLATE OF ICE

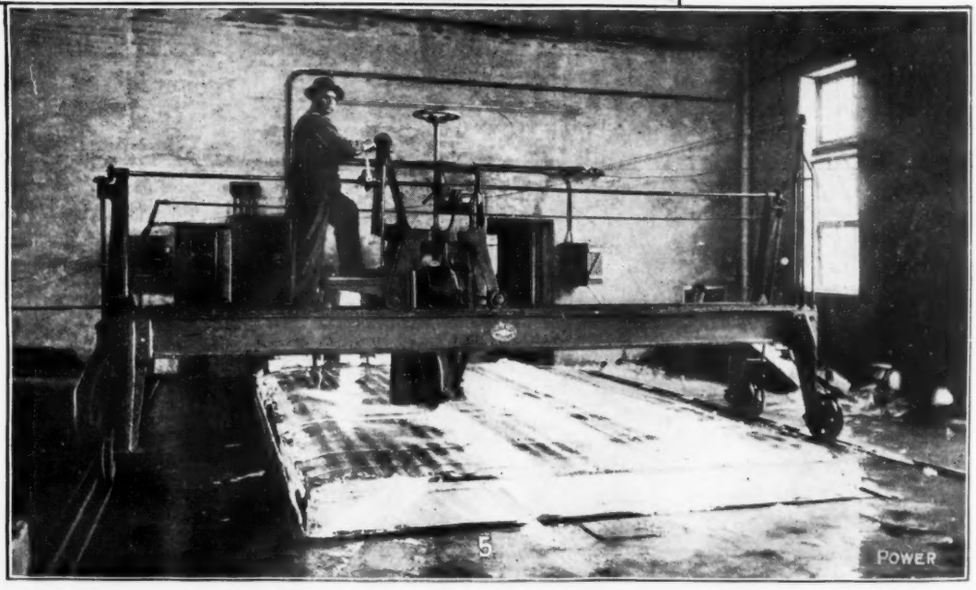


FIG. 5. SAWING THE PLATE INTO CAKES

Having followed the product from well to storage, it may be of interest to trace the ammonia. The flooded, or more properly the gravity-feed, system is employed. This entails the use of an accumulator and the coils in the tank are maintained full of liquid. Instead of installing a control or expansion valve on each coil, as in the usual direct-expansion system, and manipulating a large number of valves to regulate the varying demands for ammonia, in this installation one valve controls the entire supply. To illustrate the importance of this arrangement, it is pointed out that while freezing the first inch of ice will require about one hour, and naturally much ammonia per unit of time, the last inch will require about one day to freeze, and consequently about one-twenty-fourth the ammonia required to freeze the first inch.

With 80 valves instead of one, there would be constant need of adjustment, making it practically impossible to regulate the feed in this way. With the gravity-return system, just the amount of ammonia needed is evaporated. There is not so much necessity for regulation; an occasional turn of the one valve toward closing is the requirement to meet the decreasing demand.

A 300-ton compressor serves the ice plant. Liquid ammonia under high pressure is conveyed through a 2-in. pipe a distance of 1000 ft. This ammonia passes through a spiral coil in a chamber on top of the accumulator and is cooled by the suction vapor on its way to the compressor. Cooling the liquid to the temperature of the ammonia in the coils prevents it flashing into a fog-like mist in the accumulator, which would be carried along with the return vapor and cause trouble in the machine. From the cooling coil, the liquid ammonia enters the body of the accumulator and flows by gravity to the inlet header at the bottom of the coils. The liquid in the accumulator is maintained at the same level as the outlet header of the coils, so that the latter are kept full of liquid and their entire surface made effective. From the outlet header ammonia vapor passes off to the suction of the compressor.

In its passage through the accumulator cooling chamber the entrained liquid is retained by baffles much in the same way as in a steam separator and returned to the body of the accumulator. Thus, the feed to the coils is made up of a mixture of the liquid returned from the separator and the fresh supply from the high-pressure side. The one control valve previously mentioned is in the pipe connecting the cooling coil in the separator with the body of the accumulator.

With the arrangement described, a large number of coils may be fed in parallel. The simplicity of this arrangement and the facilities for harvesting the ice reduce the labor in the plant so that only two men are required. The initial cost of the system is comparatively high, but this is offset by the reduction of labor in harvesting, by the efficiency of the plant, the high quality of the product and the simplicity of operation.

Water-Power Developments in California to the total construction cost of $5,941,300 have been sanctioned by the state water commission, according to a recently issued report, during the two years ended Apr. 1, 1914. Since Jan. 1, 1913, twenty-one out of thirty-eight applications to appropriate water have been rejected, according to the report, either for failure to comply with rules prescribed by the commission or on the ground that the interests of the state demanded such arejection.

"Gasteam" Engines at Ford Plant

Much interest is being shown and many questions asked regarding the new power plant being built by the Ford Motor Co. at Highland Park, Detroit. This will be a combination gas and steam plant, equipped with steam boilers, gas producers and "regenerators," provision being made to utilize as much of the waste heat as possible. Each main unit, of which there are four, will consist of a two-cylinder gas engine arranged in tandem and a tandem compound condensing steam engine. These will be connected to one shaft, similar to the arrangement employed in a cross-compound steam engine, and will drive a 3750-kw. 250-volt direct-current generator at 80 r.p.m. Each unit will be capable of developing 6000 brake-horsepower.

This combination "gasteam" engine will give the economy of a gas engine and the reliability of a steam engine. Gas engines, as a rule, operate at their best when fully loaded and with a constant load. However, if operated in this manner they have no overload capacity, which results in the practice of running them underloaded. This produces wire-drawing of the gases through the valves and ports, which has a tendency to precipitate tarry matters but usually does not give trouble under full-load conditions. With the combination type of unit the engine is not intended to be put in service, unless there is a half-load or more, hence the gas side will always be fully loaded. There has been no attempt to govern the gas side other than in cases of over speeding. The steam side will do all the governing and take care of all the load fluctuations. In case of trouble on the gas side, the steam side can pull the entire load with a late steam cutoff.

The engines will be of the four-stroke-cycle, double-acting type with water cooling. Each cylinder will be 42 in. in diameter and 72-in. stroke, the same size as those of the big Ford engine installed last year; see POWER for July 22, 1913.

The tandem-compound condensing steam unit will have a high-pressure cylinder 36 in. in diameter and a low-pressure cylinder 68 in. in diameter with a stroke of 72 in. The low-pressure cylinder will be connected to a surface condenser which in turn will be placed in a closed heating system. The vacuum will be regulated to correspond to atmospheric temperatures and during the winter months it will be reduced to about 18 in. and the entire amount of circulating water will be pumped through all the factory buildings for hot-water heating. Superheated steam will be used at a pressure of 175 lb. and the high-pressure cylinder will be equipped with poppet valves, while Corliss valves will be employed on the low-pressure cylinder.

Exhaust from the gas engine will be conducted into a steam superheater located in the steam line between the high- and the low-pressure cylinders, thus utilizing waste gases for reheating the high-pressure exhaust steam. Part of the exhaust gases are shunted through the jacket of the high-pressure cylinder for the purpose of eliminating heat losses in that cylinder. The exhaust gases are then conducted to the boiler feed-water heater and will heat all the feed water required for the steam boilers.

Feed water for the heater is secured from the water used for cooling in the gas cylinder jackets, where it is

brought up to a temperature of from 150 to 180 deg. This is finally raised to a temperature of about 250 deg. in the heater by means of the exhaust gases, as previously mentioned.

It is also planned to arrange the batteries of boilers and producers in such a way that the producer gas may be passed through some of the boilers on its way to the scrubber and thus utilize much of the sensible heat for steam generation. Of course, the relatively low temperature of the producer gas will prevent forcing a boiler in this way, and it has been suggested that provision be made for burning some of the gas in the furnaces when necessary.

The engines are being furnished by the Hooven, Owens, Rentschler Co., of Hamilton, Ohio, who built the two earlier gas engines for the Ford Co., while the Crocker-Wheeler Co. is furnishing the generators and Wickes Bros. the boilers.

New Engineering Bureau for N. Y. Board of Education

It is understood that the board of education of the City of New York is about to give final consideration to the proposal that a new bureau of engineering be created, with a mechanical engineer as its executive head, to care for all engineering matters in connection with the public school buildings of that city.

For such a new bureau to go into effect in 1915, action must be taken at once for inclusion in the 1915 departmental budget. Otherwise, it must lay over for another whole year. This matter has been under consideration for a long time, in one form or another, and it is to be hoped that it has now reached a settlement.

REASONS FOR THE NEW BUREAU

At the present time engineering matters in the board of education are being handled by three separate bureaus and by many officials. The design of engineering equipments for new schools is handled by the building bureau, whose head is an architect. Under him are consulting sanitary, electric and heating engineers, each in charge of his specialty, but limited by the superior authority of the architect, head of the bureau. In the matter of installation, these designing engineers are further limited by the authority of the several deputy superintendents of school buildings, one for each of the five boroughs into which the city is divided. These deputies are also architects.

In the matter of repairs and maintenance of engineering installations, the designing engineers have almost nothing to say as the deputy superintendents of school buildings control the expenditure of all repair funds in their respective boroughs, in most cases without consultation with the designing engineers, and the several engineering inspectors, while nominally under the respective designing engineers, are actually controlled by the respective deputy superintendents. Supervision of janitors and of the operation of the heating plants, etc., is handled by a separate bureau, headed by a supervisor or janitors assisted by three assistant supervisors.

There are nearly 700 schools in the city and it is evident that these four men cannot adequately supervise the janitors, engineers, cleaners, etc., employed in these buildings. Cleanliness of the buildings is the most prominent feature of the janitorial service and as all the boilers, etc., are hidden away from view in the cellars, the latter receive but little supervisory attention hence conditions obtain which are likely to lead to unsatisfactory and uneconomical operation of the plants.

At the present time, engineering conditions in the New York City schools are in a bad way, and it is easy to understand the causes of the many criticisms of their heating and ventilation.

The Board, in its present consideration of this matter, will undoubtedly realize the necessity for divorcing engineering from architectural supervision and for consolidating, under one competent mechanical engineer, all classes of engineering, including power plants, heating and ventilating, electric and sanitary engineering, together with the selection and supervision of the operating engineers and janitors handling such installations. With such a bureau of engineering, handling all engineering matters under one head, there would be possible undivided economical operation of plants, adoption of the best practice in design and wise expenditure of repair funds, with consequent savings in costs of fuel and inspection, and more satisfactory conditions in the schools as to sanitation, ventilation, etc.

The New York Chapter of the American Society of Heating and Ventilating Engineers, at a recent meeting, unanimously passed resolutions favoring the creation of the proposed new bureau, which resolutions were transmitted to the board of education.

Chicago to Help N. A. S. E. Delegates On Their Way

To show their hospitality and to render any service possible to delegates and visitors stopping over at Chicago on their way to the National Convention at Milwaukee, Locals Nos. 1, 2, 28 and 38, N. A. S. E., of Chicago, have secured quarters at the Fort Dearborn Hotel, Van Buren and La Salle Sts. Here a committee from the joint associations, assisted by the ladies' auxiliaries of Chicago, will hold open house and do their best to welcome and entertain incoming conventioners.

Members of the committee will be in constant attendance on Saturday, Sunday and Monday preceding the convention, and will be glad to meet any or all delegates at the train. All that will be necessary is a postal to Al. Johnson, chief engineer of Mandel Bros., Chicago, Ill. The hotel is central and has a wide range of prices, so that reasonable accommodations may be secured. A hearty welcome is assured to all, and it is the hope of the committee to greet a large delegation.

PERSONALS

Charles C. Hughes has succeeded S. A. Bockius as general Western sales agent for the Elliott Co. and the Liberty Mfg. Co. His headquarters are 1542 Monadnock Block, Chicago, Ill.

William De Groot, Grand Rapids, was elected doorkeeper at the recent annual state convention of the Michigan N. A. S. E., instead of Edward Rose, Detroit, as stated in the Aug. 4 issue.

J. M. Smith, for 13 years a member of the engineering corps of the Crocker-Wheeler Co., has accepted the newly created position of engineering manager at the Triumph Electric Co.'s works, Cincinnati (Oakley), Ohio.

Frank H. Ball, who has been connected with the high-speed engine business as inventor and manufacturer since its infancy, has withdrawn from that field to engage in the manufacture and sale of carburetors. Associated with him under the firm name of Ball & Ball, at Detroit, is his son, Frederick O. Ball, until recently general manager of the American Engine & Electric Co.

NEW EQUIPMENT

WEST OF THE MISSISSIPPI

Bids will be received until Sept. 7, by the City Council, Alvord, Iowa, for constructing a municipal electric-light plant.

The Central Light & Power Co., Boone, Iowa, will build an electric-light plant in Dayton, Iowa.

Press reports state that bids will be received by the city of Topeka, Kan., until Oct. 1, for installing in the municipal electric-light plant, a 250-kw., 60-cycle, three-phase, 2300-volt turbo-alternator with exciter.

A municipal electric-light system will be constructed at North Bend, Neb. The estimated cost is $21,000.

Bids will be received by C. L. Jones, City Audr., Parker, S. D., until 10 a.m., Sept. 4, for constructing an electric-light plant. The work consists of a power station, oil engines and accessories, generators, exciters, etc., and a pole line and wiring. J. F. Druar, St. Paul, Minn., is Consult. Engr.

F. H. Mudd, Maben, Mo., has been granted a franchise to construct an electric-light plant. He is in the market for machinery.

Carl Shipp, Winnsboro, Ark., is in the market for equipment for his electric-light plant, which will be enlarged.

Bonds for $100,000 have been voted by the citizens of Mangum, Okla.; the proceeds will be used to equip an electric-light and power plant.

The Salt Lake Light & Traction Co., Salt Lake City, Utah, has been organized with a capital of $1,000,000, to establish power plants and distributing systems. O. J. Salisbury is Pres.

The San Joaquin Light & Power Co., Merced, Calif., it is reported, will double the capacity of its gas plant and will install new generating machinery. A. G. Wishon, Fresno, is Gen. Mgr.